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The North Pickering Project

**The Iterative Lowry Modelling
Exercise: Phase I:
The North Pickering Project's
Lowry Manual
[Background Paper No. 2]**



December, 1974



Ministry of
Housing

Ontario

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ABBREVIATIONS

C B D	Central Business District
M T C	Ministry of Transportation and Communications
TARMS	Toronto Area Regional Model Study
T C R	Toronto Centred Region
TEIGA	Ministry of Treasury, Economics and Intergovernmental Affairs

THE ITERATIVE LOWRY MODELLING EXERCISE:

PHASE I:

THE NORTH PICKERING PROJECT'S

LOWRY MANUAL

PART A

SECTION I INTRODUCTION

The North Pickering Project's Economic Planning staff recently conducted a regional economic modelling exercise. The purpose of this report is to document the modelling exercise.

The tool of analysis for this regional economic modelling exercise is the Lowry Model. The Lowry Model is a land use model. It has a spatial allocation dimension which permits the testing of alternate economic scenarios for North Pickering within a regional setting. The data requirements for the Model are minimal and it has a straight forward causal structure. The Model is designed to aid in evaluating the impact of public decisions on urban form.¹

The report is divided into three parts. Part A contains a summary statement on the Model, its limitations, its data requirements and selected results. Part B contains a more detailed description of the Model, the data, the computer tests and the conclusion and footnotes. Part C contains the appendix and the bibliography.

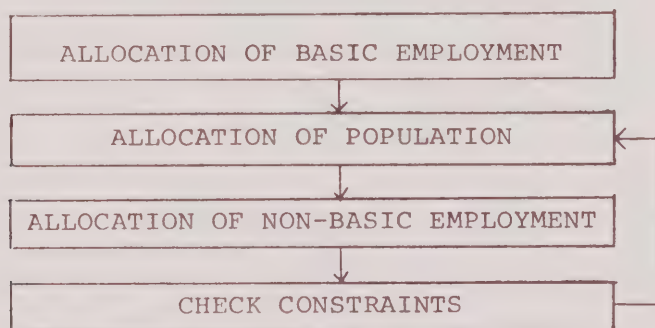
Part B is more technical than Part A and is meant to give the reader an understanding of the Model. Those interested in more detailed information on the Lowry family of models are referred to the bibliography.

SECTION II SUMMARY

1. Description of the Model

The Lowry Model made its first public appearance in 1964 in Ira Lowry's A Model of Metropolis. Since then, a family of Lowry type models has come into use.² The particular version of the Lowry Model used in this study is the Iterative Lowry Model as developed by Professor B.G. Hutchinson at the University of Waterloo.

The Lowry Model is best described in terms of the following flow chart.



The basic employment and non-basic employment terminology requires explanation. Basic employment is conventionally defined as those activities whose employment levels are chiefly determined outside the local economy and whose site selection is unconstrained by access to local markets. Non-basic employment is conventionally defined as those activities that deal directly with the local population and whose site selection and levels of employment are determined by access to this population.³ The structural characteristics of basic and non-basic employment are not emphasized as they are in export base theory. Export base theory defines basic employment as employment in the export sector and non-basic

employment as employment not in the export sector. For the Lowry Modelling exercise, the locational characteristics of employment are emphasized, therefore basic employment is site oriented and non-basic employment is population oriented.

Given the above description of basic and non-basic employment, the Model can be described in the following manner. Beginning with an exogenous allocation of basic employment by urban centre, a population to total employment ratio is applied to determine the population in an urban centre, in the first instance. Taking this population, a non-basic employment to population ratio is applied to determine the non-basic employment by urban centre, in the first instance. The constraints are checked and the population and non-basic employment generating steps are reiterated.

The Iterative Lowry Model is a restatement of Lowry's original model. Chart I in the Appendix is an algebraic description of the Iterative Lowry Model.

The Iterative Lowry Model is a static, equilibrium model. The Model assumes that people prefer to live close to where they work, as exhibited by their trip-making behaviour. The Model assumes non-basic employment locates close to population concentrations. The Model simulates population and employment distributions and develops work to home and home to shop person trip linkages between urban centres. The results tend to reflect the dominating influence of the regional parameters, especially the regional activity rate (total employment/population). In comparing the output of the Model with the input data (see page 4), it is assumed that the planning figures (input) will materialize with the correct mix of policy decisions.

2. Limitations of the Model

The Model is not without its limitations. The basic/non-basic dichotomy is not well defined. It is difficult to operationalize these concepts into specific employment breakdowns. Economic base theory would lead one to believe that urban growth is dependent upon basic employment. Hans Blumenfeld turns the economic base theory argument on its head, concluding that non-basic employment contributes more to growth.⁴ A.G. Wilson in his "Generalizing the Lowry Model" states that "it does not seem reasonable that the entire allocation of the population and non-basic sectors should depend so sensitively on the given distribution of basic employment".⁵ With reference to the two sub-models within the Lowry Model, Cordey-Hayes et al, conclude that "the models are appropriate therefore, only for strategic planning at a coarse spatial scale to determine the possible distribution of population and services resulting from a variety of dispositions of basic employment, transport networks and population constraints".⁶ It is in this latter context that the Iterative Lowry Modelling Exercise was conducted.

3. Data

Data exist by urban centre for the years 1971 and 1986. The area under examination corresponds to the former Zone 1 of the Toronto Centre Region (TCR) Concept. This approximates the area from Bowmanville in the east to Hamilton in the west through Richmond Hill in the north. The area is divided into thirty-seven (37) urban centres.⁷ Metro Toronto consists

of sixteen (16) urban centres. Hamilton consists of five (5) urban centres. Most of the data are from the Toronto Area Regional Model Study (TARMS) data bank of the Ministry of Transportation and Communications (MTC). One base set of data was used for all of the computer tests. The different Model runs tested the impact of changes in this base set of data as it pertained to the region and to North Pickering.⁸

The Model requires the following data; population, employment, travel times and population constraints. Data under each category were collected for the years 1971 and 1986. 1971 is the most recent year for which the required data are available. 1986 was arbitrarily chosen as a planning horizon to represent the "near" future as opposed to the "far" future, i.e. the year 2001.

Population

- a) 1971 populations by urban centre from TARMS.
- b) 1986 populations by urban centre as developed by the Regional Planning Branch of the Ministry of Treasury, Economics and Intergovernmental Affairs (TEIGA). The 1986 figures are TCR trends and commitment figures except for Oshawa/Whitby which was increased from 170,000 to 195,000 and for North Pickering which was tested through a population range of 25,000 to 103,000.
- c) As trends and commitment figures the population figures are acceptable.

Employment

- a) 1971 by urban centre from TARMS.
- b) 1986 employment by urban centre is based upon the 1986 populations and an interpolation of 1971 and 2001 TARMS employment data.
- c) Basic employment is site oriented, non-basic employment is population oriented.

- d) The figures used in this exercise represent an employment supply forecast, i.e. forecasting the number of job seekers from the given population. A more acceptable forecast would be an employment demand forecast whereby the number of jobs by employment group is forecasted.

Travel Times

- a) 1971 and 2001 peak and off peak travel times between urban centres were averaged to obtain 1986 peak and off peak travel times.
- b) 2001 trip time assumptions are based on TARMS freeway networks and anticipated levels of travel demand.
- c) More work is required in determining future intra- and inter-urban travel times.

Population Constraints

- a) Required as holding capacities for the urban centres.
- b) Information was collected from the following sources:
- Ministry of Environment sewerage constraints
 - 1969 Department of Municipal Affairs, Official Plan Study
 - Discussions with Plans Administration Branch, TEIGA (now Ministry of Housing)
- c) Projected population figures were used as the constraints because the constraint data collected was not consistent for all urban centres.
- d) A reading of municipal desires may serve as a more useful population constraint. A realistic maximum constraint for the 1986 horizon is required. The sewerage constraint figures were so large in many instances as not to be constraints at all. Municipal population desires, although perhaps high, could serve as a proxy for population constraint figures because they would be in the right

"ball park" and would be consistent within the municipal jurisdiction.

These remarks concerning the data emphasize that the results of this exercise must be interpreted with caution. A stronger data base would increase confidence in the results, but even so, the interpretation of the results of using a tool such as the Lowry Model should always be framed in terms of trends and attractivities and not in terms of absolutes.

SECTION III SELECTED RESULTS

The initial computer runs were conducted to calibrate the Model on 1971 data. The calibration runs successfully simulated the population and employment distributions. Preliminary comparison of the Model's trip linkages with MTC's specific purpose travel information indicate compatibility at a very general level.

Four different sets of Forecast computer runs for 1986 were conducted. All runs were designed to test alternate roles for North Pickering within its regional setting. The variation of results within the individual sets of computer runs was minimal. However, substantial differences did occur between the sets of Forecast computer runs. Through the cross comparison of these sets of runs, a better understanding of the Model and, to the extent that the Model represents urban interactions, a better understanding of the urban process can be gained. Such comparisons indicate the importance of the basic/non-basic employment split, and the travel times to the results.

Charts IV-A and IV-B in the Appendix, compare in percentage terms the Model's results with the given data. In Part B, Section VI,

selected 'over and under allocations' are presented in tabular form as 'Model Results'. In the context of this exercise, these over and under allocations represent the Model's assessment of the viability of the assumptions being tested.

The Lowry Model is geared to testing alternate hypotheses. The basic/non-basic split, the travel times, the roles of North Pickering and Oshawa/Whitby were altered to test different situations. Results from these tests consistently showed North Pickering as unattractive to population and Oshawa/Whitby as consistently attractive to population. North Pickering's strongest work and shop linkages were with Scarborough and Oshawa/Whitby. The Model also indicated Hamilton, Mississauga, Metro Toronto and Oshawa/Whitby as the major work and shopping nodes in the region.

The remainder of this Section is devoted to a summary statement on each Forecast computer run and to selected results. A detailed report on all of the computer runs is given in Part B, Section VI.

Forecast I

The purpose of the Forecast I computer set was to test the Model simulation, using a large role for North Pickering within its regional setting, given the general data base. For a detailed description of the data base, see Part B, Section VI. Basic employment is quantified as manufacturing employment plus wholesale employment plus other employment (Primary) plus fifty percent of service employment. Non-basic employment is quantified as retail employment plus fifty percent of service employment.

Two different economic scenarios for North Pickering

were tested in the Forecast I computer set: a large population, 80,000 assuming no airport; a larger population, 103,000 assuming an airport. The rationale for the alternate roles for North Pickering is contained in Part B, Section VI.

Diagram I (below) provides population, employment and home to work trip linkage results for selected centres for the Forecast I, 103,000 North Pickering role, computer run. The centre square in Diagram I describes the rows and columns. The rows in order are Population, Total Employment, Basic Employment. The columns in order are Given (input) and Model (output). The number within the brackets refers to the number of people who live and work in that urban centre. The percentage figure represents the number of workers who live and work in that urban centre as a percentage of workers who travel to work in this urban centre. It should be noted that this percentage is relatively small in all urban centres except Oshawa/Whitby, indicating a high degree of commuter movement in the region. There is no Model-Basic Employment entry.

The arrows in Diagram I indicate the flow of workers to an urban centre as a percentage of the total employment in that centre. The home to shop trip linkages for the different Forecast computer sets are included in the Appendix.⁹

Diagram I indicates a balanced percentage flow of workers between Oshawa/Whitby and North Pickering. However, in absolute terms, more workers travel from North Pickering to work in Oshawa/Whitby than travel from Oshawa/Whitby to work in North Pickering. The imbalanced flow of workers between North Pickering and Scarborough should be noted. Many more workers travel from Scarborough to work in North Pickering

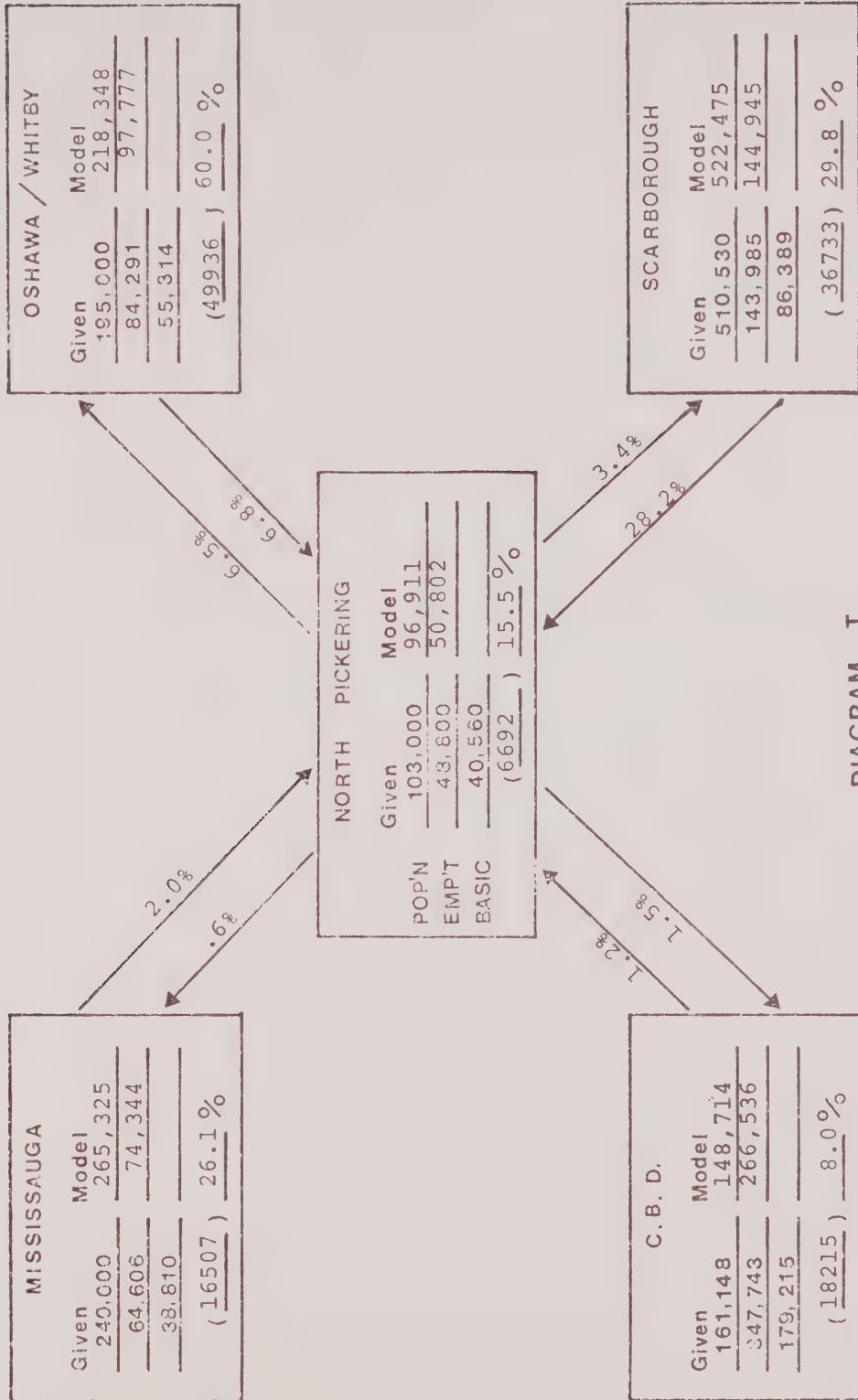


DIAGRAM I

FORECAST I - IV
HOME TO WORK FLOW
AS A % OF TOTAL WORK FLOWS

than travel from North Pickering to work in Scarborough.

As noted earlier it is the trends rather than the absolute figures provided in this and the following Diagrams which ought to be considered when appraising the results.

Forecast II

The purpose of the Forecast II computer set was to test the Model simulation, using a large role for North Pickering within its regional setting, and the general data base while providing a more specific basic employment figure for each urban centre. For this purpose basic employment is quantified as manufacturing employment plus wholesale employment plus other employment plus a percentage of service employment. Non-basic employment is quantified as retail employment plus the remaining percentage of service employment.

Three different economic scenarios for North Pickering were tested in the Forecast II computer set: a large role, 80,000 for North Pickering assuming no airport; a larger role, 103,000 for North Pickering assuming an airport; and the larger role, 103,000 for North Pickering assuming an airport and altering the basic/non-basic employment split. The rationale for the alternate roles for North Pickering is contained in Part B, Section VI.

Diagram II (below) provides the population, employment and home to work linkages for selected urban centres for the Forecast II, 103,000 North Pickering role, computer run.

Forecast III

The purpose of the Forecast III computer set was to test the Model simulation using a smaller role for North Pickering and alternate roles for Oshawa/Whitby while maintaining the general data base and the specific basic employment figures for all urban centres.

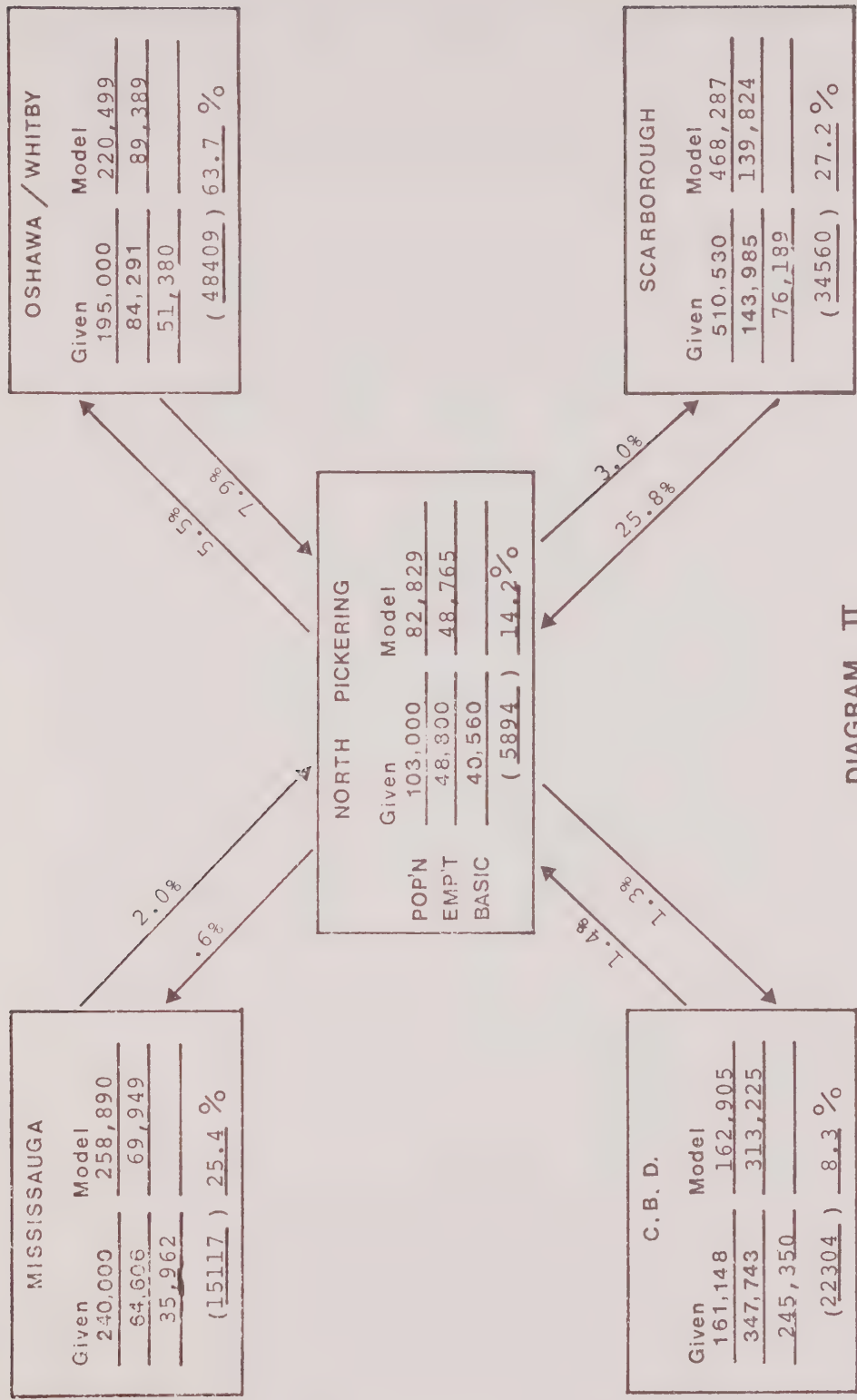


DIAGRAM II

FORECAST II -X
HOME TO WORK FLOW
AS A % OF TOTAL WORK FLOWS

The Malton and Toronto central business district (CBD) percentages of service employment quantified as basic employment were increased, otherwise, the ratios generated for Forecast II were retained. Travel times between some centres were also altered.

Two different economic scenarios for Oshawa/Whitby were tested in the Forecast III computer set: a trends and commitment role for Oshawa/Whitby, 195,000 population; and a goals role for Oshawa/Whitby, 260,000 population. For both of these tests, a smaller role of 40,000 population for North Pickering was used. Both of these tests assumed an airport. The rationale for the alternate roles is contained in Part B, Section VI.

Diagram III-A (below) provides the population, employment and home to work trip linkages for selected urban centres for the Forecast III, Oshawa/Whitby 195,000 role, computer run.

Diagram III-B (below) provides the population, employment and home to work trip linkages for selected urban centres for the Forecast III Oshawa/Whitby 260,000 role, computer run.

Forecast IV

The purpose of the Forecast IV computer set was to test the Model simulation with a small role for North Pickering while maintaining the specific basic employment figures for all urban centres. The general data base was used.

Two economic scenarios were tested: a small role for North Pickering, 25,000 population, assuming no airport and a small role for North Pickering, 25,000 population assuming no airport and without the normal population constraint. The normal population constraint used in all Forecast computer sets is fifteen percent maximum over allocation. The rationale for the alternate roles is contained in Part B, Section VI.

Diagram IV provides the population, employment and home to work trip linkages for selected urban centres for the Forecast IV, North Pickering population unconstrained role, computer run.

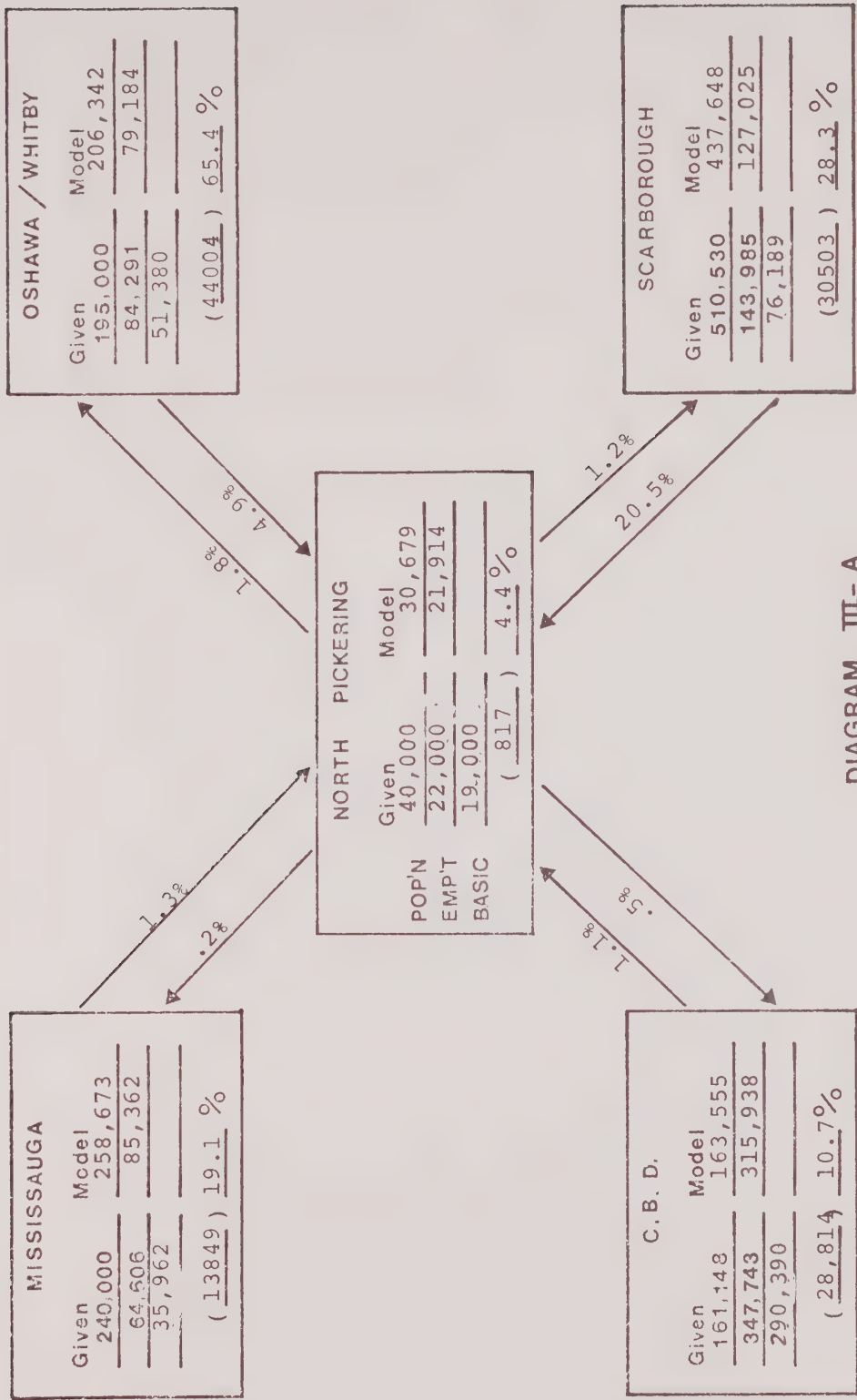


DIAGRAM III-A

FORECAST III -XV
HOME TO WORK FLOW
AS A % OF TOTAL WORK FLOWS

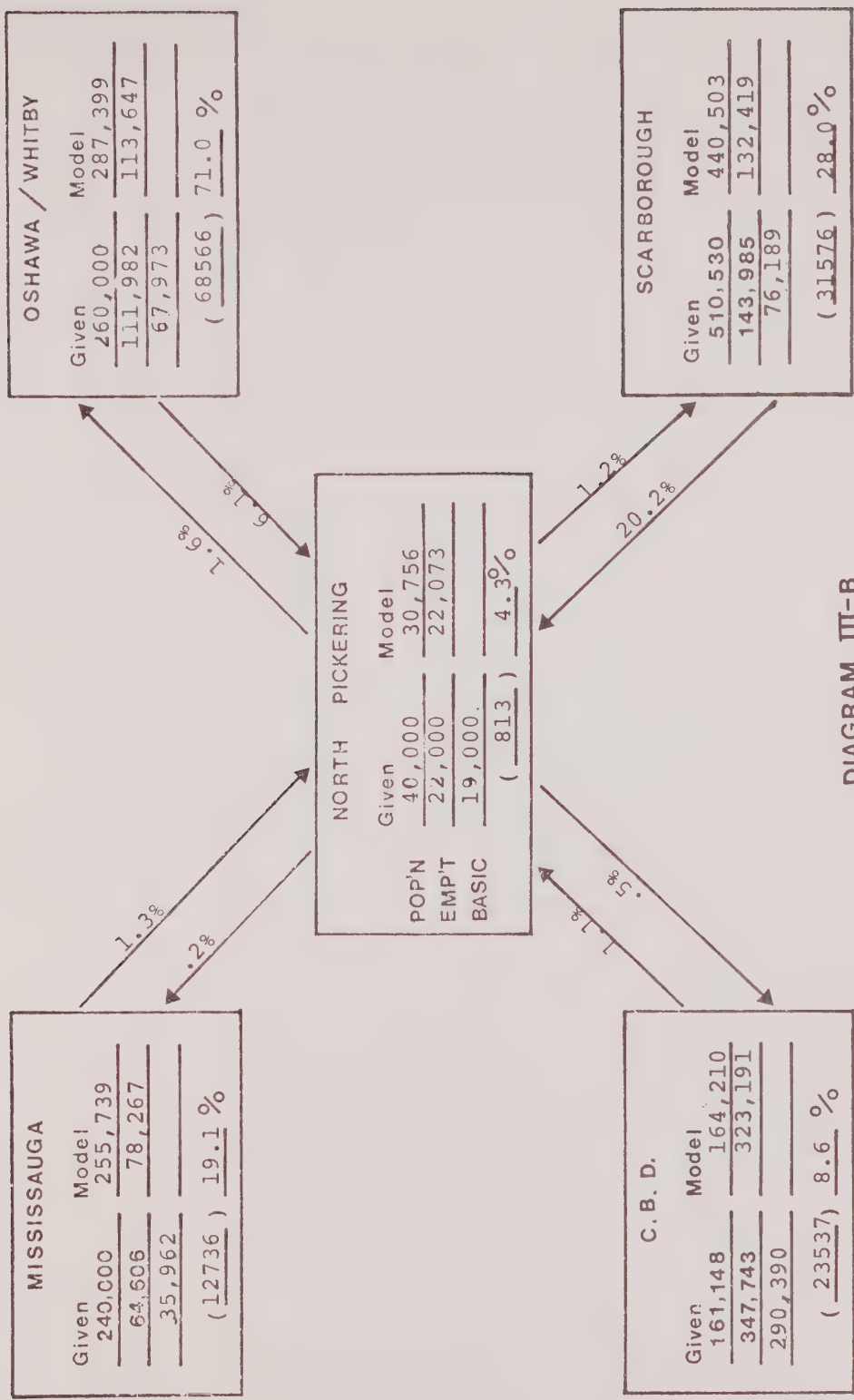


DIAGRAM III-B

FORECAST III-XVI

HOME TO WORK FLOW
AS A % OF TOTAL WORK FLOWS

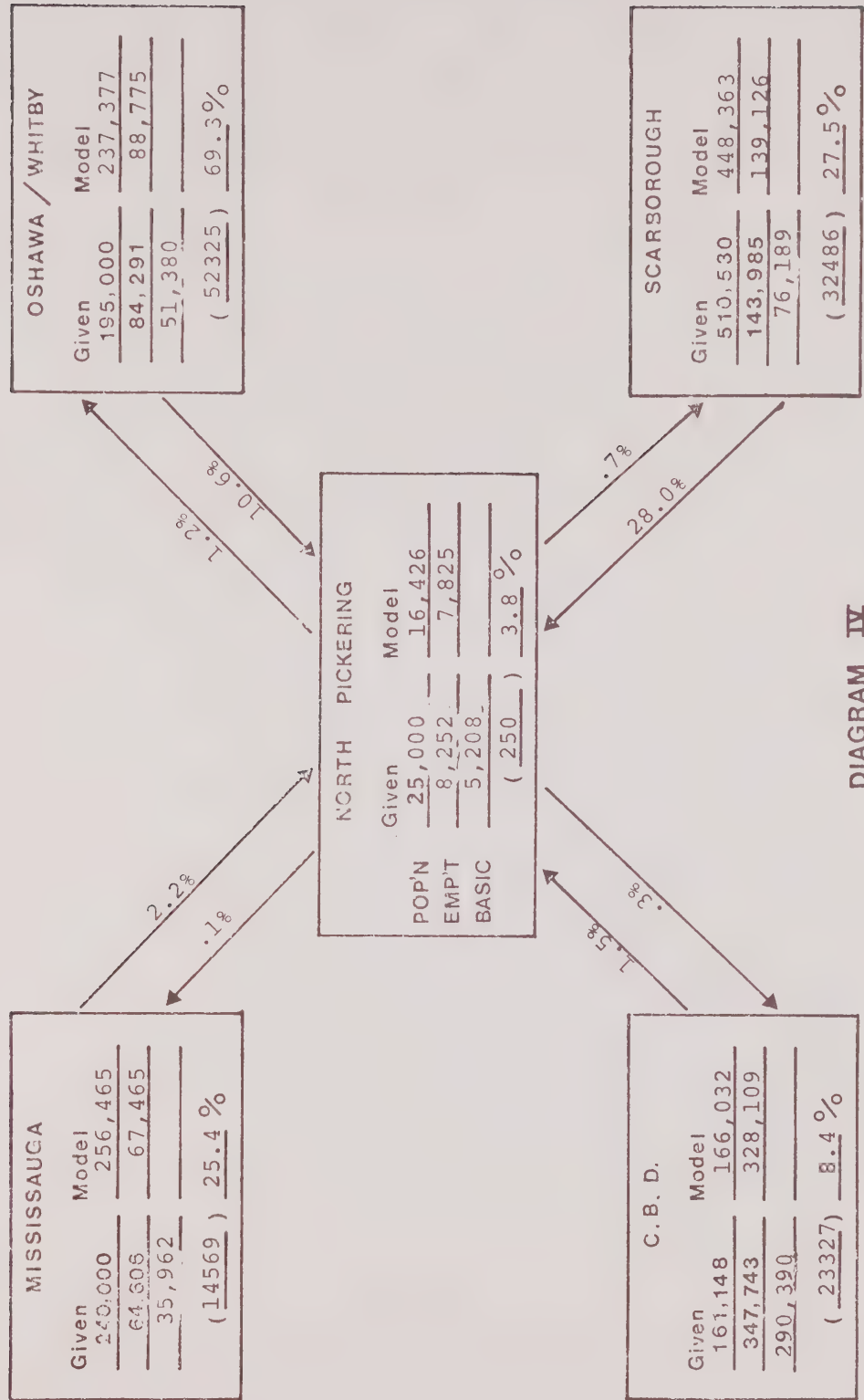


DIAGRAM IV

FORECAST IV-XIX
HOME TO WORK FLOW
AS A % OF TOTAL WORK FLOWS

PART B

SECTION IV THE MODEL

Familiarity with the general flow structure of the Lowry Model as presented in Section II is not sufficient to understand the Model nor to interpret its results. This Section of the report is designed to introduce the reader to the equation-structure of the Iterative Lowry Model and to guide the reader through the six modules or exercises which constitute the Iterative Lowry Model. These modules are:

1. the Calibration Module
2. the Population Allocation Module
3. the Non-Basic Employment Allocation Module
4. the Linking Module
5. the Work to Home Journey Simulation Module
6. the Home to Shop Journey Simulation Module

A competent understanding of the Model, its assumptions and structure should provide a strong basis for intelligent interpretation of the Iterative Lowry Model's results.¹⁰

Before describing the six modules of the Iterative Lowry Model, the basic equations will be presented.

The first equation (below) pertains to the Calibration Module, the Population Allocation Module and the Work to Home Journey Simulation Module.

$$T_{ij}^w = e_i \frac{H_j e^{-\alpha d_{ij}^w}}{\sum_j H_j e^{-\alpha d_{ij}^w}} \quad (1)$$

Where

- T_{ij}^W represents the number of work to home trip links from employment zone i to residential zone j .
- e_i represents total employment in employment zone i .
- H_j represents a population attractivity factor reflecting the population capacity in residential zone j .
- $e^{-\alpha d_{ij}^W}$ represents an exponential travel time factor where α represents the sensitivity to travel time for the work to home trip and where d_{ij}^W represents the work to home travel times between employment zone i and residential zone j .

The second equation (below) pertains to the Calibration Module, the Non-Basic Employment Allocation Module and the Home to Shop Journey Simulation Module.

$$T_{ij}^S = P_i \frac{e_j^S e^{-\beta d_{ij}^S}}{\sum_j e_j^S e^{-\beta d_{ij}^S}} \quad (2)$$

Where

- T_{ij}^S represents the number of home to shop (where shop is equated to non basic employment) trip links of population serving employees in employment zone j serving households in residential zone i .
- P_i represents population in residential zone i .
- e_j^S represents a non-basic employment attractivity factor reflecting non-basic employment in employment zone j .
- $e^{-\beta d_{ij}^S}$ represents an exponential travel time factor where β represents the sensitivity to travel time for the home to shop trip and where d_{ij}^S represents the home to shop travel time between residential zone i and employment zone j .

The following paragraphs indicate how equations (1) and (2) are employed within the Iterative Lowry Model.

1. The Calibration Module

The purpose of the Calibration exercise is to determine parameters which will accurately reflect the sensitivity of trip makers to travel times for the work to home and the home to shop trips, respectively. These parameters are used in the actual running of the Iterative Lowry Model.

The Calibration exercise employs equation (1) to determine the work to home trip parameter. T_{ij}^W , e_i , H_j , dij^W are given from the base year data (1971); α is determined.

Similarly equation (2) is used to determine the home to shop trip parameter. T_{ij}^S , P_i , e_j^S , dij^S are given from the base year data (1971); β is determined.

In the Calibration exercise T_{ij}^W is the mean of the work to home trip frequency distribution which was obtained from the Ministry of Transportation and Communications. Similarly, T_{ij}^S is the mean of a trip frequency distribution which describes the home to shop trip.

The α and β are determined from base year data. The larger the value of the parameter, the larger will be the role of travel times in population and employment location decisions i.e. the larger the parameter the smaller the distance people will travel.

The α and β parameters determined from base year data are used in the horizon year i.e. in using the Model for policy testing. This does not mean that the trip time frequency distribution of the present is assumed for the future. It does mean that the sensitivity of trip makers to travel time will not change in the future. It should also be noted that models calibrated in terms of dij are very sensitive to changes in the parameter magnitudes and to the accuracy of the travel time measurement.¹¹

2. The Population Allocation Module

The purpose of this exercise is to allocate the population associated with the total employment. The population figures derived from this exercise are then used as input into the Non-Basic Employment Allocation Module. The α parameter from the Calibration exercise is utilized in this exercise.

The Population Allocation Module employs the following variation of equation (1):

$$T_{ij}^w = e_i \cdot k \cdot \frac{H_j \cdot e^{-\alpha \cdot dij^w}}{\sum_j H_j \cdot e^{-\alpha \cdot dij^w}} \quad (3)$$

Where T_{ij}^w , e_i , H_j , $e^{-\alpha \cdot dij^w}$ are defined as in equation (1) and where k represents the inverse of the activity rate i.e. population/total employment.

H_j , dij^w , k are given. α is determined from the calibration exercise. A "best guess" is used as the initial entry for total employment; simulated total employment is used thereafter. Given the above factors, T_{ij}^w is determined. The summation of the work to home trip links with respect to the residential zones gives the population allocation. In mathematical terms, $\sum_j T_{ij}^w = P_j$. This relationship between population and employment is a direct result of including the inverse of the activity rate in the equation. If the simulated population in each zone exceeds the population attractivity factor (H_j) by more than the allowable over allocation error then the population attractivity factor is reduced and T_{ij}^w and $\sum_j T_{ij}^w$ are recalculated. A maximum population over allocation error of fifteen per cent is used in this exercise. The Model will not over allocate

population to any one zone by more than fifteen per cent. The Model is not constrained in under allocating population.

3. The Non-Basic Employment Allocation Module

The purpose of this exercise is to allocate the non-basic employment associated with the population. The simulated non-basic employment is then used in the Linking Module. The β parameter from the Calibration exercise is utilized in this exercise.

The Non-Basic Employment Allocation Module employs the following variation of equation (2):

$$T_{ij}^S = P_i \cdot m \cdot \frac{e_j^S \cdot e^{-\beta dij^S}}{\sum_j e_j^S \cdot e^{-\beta dij^S}} \quad (4)$$

Where T_{ij}^S , P_i , e_j^S , $e^{-\beta dij^S}$ are defined as in equation (2) and where m represents the non-basic employment to population ratio.

dij^S , m are given. β is determined from the Calibration exercise. P_i is determined from the Population Allocation exercise, where $i=j$. A "best guess" is used as the initial entry for non-basic employment; simulated non-basic employment is used thereafter. Given the above factors T_{ij}^S is determined. The summation of the home to shop trip links with respect to the work zone gives the allocation of the simulated non-basic employment. In mathematical terms, $\sum_j T_{ij}^S = e_j^S$

This relationship between population and non-basic employment is a direct result of including the non-basic employment to population ratio in the equation. The Model as used in this exercise was not constrained in terms of non-basic employment.

4. The Linking Module

This exercise is the linking of the Population Allocation Module and the Non-Basic Employment Allocation Module. Its purpose is to obtain a revised estimate of total employment. The simulated non-basic employment from the third exercise is added to an exogenously determined basic employment to give simulated total employment. This simulated total employment is then used in the second exercise to replace the "best guess" total employment entry. Once the Model has reached the Linking exercise it returns to the second exercise and repeats the second, third and fourth exercises. The Model no longer uses "best guesses" but uses simulated figures from the previous iteration of the Model. Exercises two, three and four are repeated until convergence is reached. Convergence is assured in the Population Allocation Module by the attractiveness factor and the maximum over allocation error. The change in the population figures gradually diminishes. The change in the non-basic employment diminishes as well. Since the simulated non-basic employment is added to the static basic employment, the change in total employment diminishes until convergence is reached.

5. The Work to Home Journey Simulation Module

The purpose of this exercise is to simulate the work linkages within the area of study. The following variation of equation (1) is used:

$$T_{ij}^{gw} = e_i g^w \frac{H_j e^{-\alpha_{ij}^w}}{\sum_j H_j e^{-\alpha_{ij}^w}} \quad (5)$$

Where e_i , H_j , $e^{-\alpha_{ij}^w}$, are defined as in equation (1) and where g^w represents the work trip generation rate (trips per employee) which is provided exogenously.

The result of this exercise is T_{ij}^{gw} , the number of work to home trip links distributed from work zone i to residential zone j.

6. The Home to Shop Journey Simulation Module

The purpose of this exercise is to simulate the shop linkages within the area of study. The following variation of equation (2) is used:

$$T_{ij}^{gs} = P_i \cdot g^s \cdot \frac{e_j^s \cdot e^{-\beta d_{ij}^s}}{\sum_j e_j^s \cdot e^{-\beta d_{ij}^s}} \quad (6)$$

Where P_i , e_j^s , $e^{-\beta d_{ij}^s}$ are defined as in equation (2) and where g^s represents the shop trip generation rate which is provided exogenously.

The result of this exercise is T_{ij}^{gs} , the number of home to shop trip links distributed from residential zone i to shop zone j.

SECTION V THE DATA

The study area for this Modelling exercise is the former Zone 1 of the Toronto Centred Region Concept. This approximates the area between Bowmanville in the east and Hamilton in the west through Richmond Hill in the north. Eighteen urban envelopes or centres have been designated by the TCR Concept within this area. The Iterative Lowry Modelling exercise has built upon this structure by increasing the number of urban centres to thirty-seven. Hamilton was increased from one to five urban centres. Metro Toronto was increased from one to

sixteen urban centres.¹²

For each of the thirty-seven urban centres, population, employment and travel time information was collected. The following paragraphs outline this collection of data and the manipulation of the data for the 1971 Calibration run and for the 1986 general data base. The 1986 data manipulations specific to particular computer tests are presented in Section VI.

The 1971 population data for the thirty-seven urban centres were obtained from the Ministry of Transportation and Communications' TARMS Data Bank. The TARMS Data Bank consists of land use data at the traffic zone level. These traffic zones are aggregated to various levels, one of which is the urban envelope or centre. The May, 1973, TARMS Data Bank computer print-out provided the population data.

The 1971 employment data for the thirty-seven urban centres were also obtained from MTC's May, 1973 TARMS Data Bank computer print-out. Total employment data are disaggregated into manufacturing and wholesale, retail, service and other employment. This disaggregation is based on an aggregation of the twelve major Standard Industrial Code Classifications.

For the Iterative Lowry Modelling exercise, total employment must be divided into basic and non-basic employment. In order to render basic and non-basic employment into quantitative terms, the following definitions were used:

Basic employment = manufacturing + wholesale + other +
50% of service

Non-Basic employment = retail + 50% of service

The TARMS employment data were aggregated according to the above definitions to obtain basic and non-basic employment

for the thirty-seven urban centres.

The 1971 travel time information was obtained from MTC in the form of 1971 peak and off-peak travel times between traffic zones. Representative traffic zones for the urban centres were chosen and the times between them served as the times between the urban centres. The peak travel times were used as the work to home travel times; the off-peak travel times were used as the home to shop travel times.¹³

Intra-centre travel times were obtained by averaging the travel times between certain traffic zones within the urban centres. It was found that the intra times were higher, relative to the inter times, than would be expected. This was attributed to the large size of the urban centres.

Travel trip time frequency distributions for the home to work and home to shop travel trips were obtained from MTC. These distributions were obtained by transportation districts, not by urban centres, as would have been preferred. It should be noted that home to work and not the work to home travel trip time frequency distribution was used. It was assumed that home to work and work to home travel times are symmetrical. The 1971 peak travel times included a terminal time factor which was subtracted in order to obtain straight peak times between centres. A Firm Survey carried out during the summer of 1973 indicated that the MTC trip time frequency distributions were accurate.

The 1971 off-peak travel times were not available for the 1971 calibration run, therefore a factor of the peak times was used. The formula used was to subtract 20% from all times in the west including Woodbridge (west of Metro Toronto) and to subtract 30% from all times in Metro Toronto and to the east and to the north. Further information on 1971 trip time

data is included in the description of the Calibration run in Section VI.¹⁴

The 1986 population for the thirty-seven urban centres was obtained from the Regional Planning Branch, TEIGA. The population figures represent TCR trends and commitments population, except for Oshawa/Whitby which has been raised from 175,000 to 195,000 and for North Pickering which has been raised from 15,000 to 25,000 to 103,000. The population for the sixteen Metro Toronto urban centres (Districts) was obtained by using the following formula by individual District:

$$\frac{1971 \text{ Metro Population}}{1971 \text{ Metro District Pop'n}} = \frac{1986 \text{ Metro Population}}{1986 \text{ Metro District Pop'n}} =$$
$$\frac{2001 \text{ Metro Population}}{2001 \text{ Metro District Pop'n}}$$

The 1971 and 2001 data was provided by the TARMS Data Bank. The 1986 Metro District population was determined as the average of two rates of growth. A similar procedure was used for Hamilton.

The 1986 employment data was obtained through an interpolation of 1971 and 2001 employment data from the TARMS Data Bank. The 1986 population data was used in this exercise. The formula was:

$$\frac{1971 \text{ Population}}{1971 \text{ Total Employment}} = \frac{1986 \text{ Population}}{1986 \text{ Total Employment}} =$$
$$\frac{2001 \text{ Population}}{2001 \text{ Total Employment}}$$

Having obtained the total employment for 1986 by urban envelope, the following formula was used to determine the total employment breakdown into manufacturing and wholesale:

$$\frac{1971 \text{ Total Employment}}{1971 \text{ Manufacturing} + \text{Wholesale}} = \frac{1986 \text{ Total Employment}}{1986 \text{ Manufacturing} + \text{Wholesale}} =$$
$$\frac{2001 \text{ Total Employment}}{2001 \text{ Manufacturing} + \text{Wholesale}}$$

Similarly, retail employment and other employment were determined for 1986. Basic and non-basic employment were obtained by using the following definitions:

$$\text{Basic employment} = \text{Manufacturing} + \text{Wholesale} + \text{Other} \\ + 50\% \text{ of Service}$$
$$\text{Non-Basic employment} = \text{retail} + 50\% \text{ of Service}$$

The 1986 travel times were obtained by averaging the 1971 and 2001 travel times by urban centre. As with the 1971 off-peak times, the 2001 off-peak times were a factor of the peak times. The same formula was used with 2001 off-peak times as for the 1971 off-peak times.

The work trip generation rate used in 1971 and 1986 was .85. The shop trip generation rate used in 1971 and 1986 was .72. These trip generation rates were supplied by Professor B.G. Hutchinson, University of Waterloo, (Transport Group).

SECTION VI THE COMPUTER TESTS

1. Calibration

The Iterative Lowry Model was calibrated using 1971 data. The Calibration exercise makes use of total employment, population attractivity factor and work to home travel times to determine the work to home trip sensitivity parameter. Similarly, Population, non-basic employment attractivity factor and home to shop travel times are used to determine the home to shop trip sensitivity parameter. The Model was calibrated on the mean of the trip time frequency distribution for work and shop trips. In order to obtain a "good fit" it was necessary to alter the travel times "across the board". For the peak times

(work to home) the intra centre times were decreased by 8 minutes, then 5 minutes were added to all times. For the off-peak times (home to shop) all times were decreased by 5 minutes. The result of the Calibration process are the α 's, the work trip sensitivity parameter and the β 's, the shop trip sensitivity parameter. The Model was calibrated to eight Districts and not to the thirty-seven urban centres.¹⁵ The α and β values are contained in Table 1.

TABLE 1

<u>ITERATIVE LOWRY α AND β VALUES</u>			
District	Appropriate Urban Centre by number	α Value	β Value
1	18-33	.0420	.0460
2	9-12	.0370	.1030
3	13-15	.0680	.1580
4	16-17	.1440	.1680
5	6-8	.0780	.1170
6	5	.1180	.2150
7	2-4	.0990	.1640
8	1, 34-37	.0840	.1070

See Chart VI, Appendix to correlate numbers and urban centres.

The first run of the Iterative Lowry Model was the 1971 Calibration run. The purpose of this run was to test the ability of the Model to simulate an existing situation. 1971 population was used as the measure of population attractivity for the urban centres. Similarly, 1971 non-basic employment was used as the measure of non-basic employment attractivity for the urban centres. Selected population and employment results are listed below. The simulations closely matched the observed 1971 population and employment data. The simulated linkages, in general terms, compare with MTC trip information.

TABLE 2

1971 Calibration Run - Selected Results

Zone	<u>Population</u>		<u>Total Employment</u>		Ranked Sources of Workers	Ranked Areas for Shopping
	Given	Simulated	Given	Simulated		
North Pickering (14)	2,415	1,564	467	430	Scarboro W. East York Oshawa/Whitby	Toronto CBD Oshawa/Whitby Scarboro W.
Oshawa/Whitby (16)	113,240	119,583	45,750	51,976	Oshawa/Whitby Ajax Scarboro W.	Oshawa/Whitby Ajax Toronto CBD
Scarborough N. (33)	41,008	34,270	6,085	5,401	Scarboro W. East York York	Toronto CBD Toronto N. York
Toronto CBD	120,879	124,472	303,212	281,195	Toronto W. East York Toronto N.	Toronto CBD Toronto N. York

Regional Population Correlation Co-efficient .99220

Regional Total Employment Correlation Co-efficient .99786

Input

North Pickering activity rate .193

Regional activity rate .403

North Pickering non-basic employment to population rate .040

Regional non-basic employment to population rate .1463

2. The Outputs of the Model

The outputs of the model are simulated population, simulated employment (total and non-basic), the work to home trip links and the home to shop trip links. A population simulation greater than the given population indicates that the urban centre is attractive to population. An activity rate in the urban centre smaller than the regional activity rate or a large exogenous allocation of basic employment may explain the population attrac-

tivity of the urban centre. An employment simulation greater than the given employment indicates that the centre is attractive to employment. A simulated population allocation larger than the projected population or a non-basic employment to population ratio in the urban centre larger than the regional ratio may explain the employment attractiveness of the urban centre.¹⁶ The ranking of work links indicates where the labour force of the particular urban centre will reside. The ranking of shop links indicates where the population of a particular urban centre will shop. In each case, the rankings indicate the strongest linkages.

Four different sets of Forecast computer runs were made with the 1986 data. Each of these sets of computer runs was designed to test alternative roles for North Pickering within its regional setting.

3. Forecast I

The Forecast I computer set was designed to test the model simulation with a large role for North Pickering, within its regional setting, given the general data base. Two different tests were made. Each test employed a different economic scenario for North Pickering.

Economic Scenario - North Pickering - Forecast I - IV

Population	103,000
Total employment	48,800
Basic employment	40,560
Non-basic employment	8,240
Population constraint	115,000
North Pickering activity rate	.473
Regional activity rate	.414
North Pickering non-basic employment to population rate	.08
Regional non-basic employment to population rate	.158

The rationale for the North Pickering population is rapid growth between 1976 and 1986. It is felt that this will be necessary to enable the new town to establish its own identity. Population increases in the order of 6,000 per year in the earlier years increasing to 8,000 per year in the later years would give the new town a population of 80,000 by 1986.

This scenario assumes an airport for North Pickering. Assuming one airport employee in three lives in the town of North Pickering and assuming an activity rate of .33 for airport employees, then the addition of an airport with 22,600 jobs will result in a town plus airport population of 103,000 by 1986. The one in three airport employee who lives in North Pickering is double the Malton experience. It is assumed that there will be fewer alternate places to live within a comparable distance.

The employment assumption for the new town of 80,000 is an activity rate of .33 resulting in 26,200 jobs. A low activity rate was assumed because of the nature of new towns, i.e. young families. The addition of 22,600 airport jobs gives the total employment figure of 48,800. The non-basic employment to population rate was assumed to be .08. Given a town population of 80,000 this results in 8,240 non-basic jobs. If the 22,600 airport jobs are treated as basic employment this results in a total of 40,560 basic jobs ($26,200 - 8,240 + 22,600$) for the town and airport combined.

Basic and non-basic employment for the remaining centres were derived from the following equations:

$$\text{Basic employment} = \text{manufacturing} + \text{wholesale} + \\ \text{other} + 50\% \text{ of service}$$

Non-basic employment = retail + 50% service

All other data has been described in Section V. Selected results are presented in Table 3.

TABLE 3

Forecast I - IV Selected Results

Zone	<u>Population</u>		<u>Total Employment</u>		Ranked Sources of Workers	Ranked Areas for Shopping
	Given	Simulated	Given	Simulated		
North Pickering (14)	103,000	96,911	48,800	50,802	Scarboro N. Scarboro W. Oshawa/Whitby	Oshawa/Whitby N. Pickering Scarboro N.
Oshawa/Whitby (16)	195,000	218,348	84,291	97,777	Oshawa/Whitby Pickering Ajax	Oshawa/Whitby Ajax Pickering
Scarborough (33)	140,866	155,556	31,449	38,461	Scarboro W. Scarboro N. East York	Toronto CBD Toronto N Scarboro W
Toronto CBD (18)	161,148	148,714	347,743	266,536	Toronto W. Toronto N. East York	Toronto CBD York Toronto N.

Regional Population Correlation Co-efficient .97824

Regional Total Employment Correlation Co-efficient .98463

Areas of Population Pressure¹⁷

Hamilton, Burlington, Erin Mills-Meadowvale, Malton, Oshawa/Whitby, Ajax, parts of Metro Toronto (North York and Scarborough).

Economic Scenario - North Pickering - Forecast I - V

Population	80,000
Total employment	26,200
Basic employment	17,960
Non-basic employment	8,240
Population constraint	100,000
North Pickering activity rate	.327
Regional activity rate	.411
North Pickering non-basic employment to population rate	.103
Regional non-basic employment to population rate	.159

This scenario differs from Forecast I - IV only in that it assumes no airport. The rationale remains the same. The reader will note the low activity rate for North Pickering. Selected results are presented in Table 4.

TABLE 4

Forecast I - V Selected Results

Zone	<u>Population</u>		<u>Total Employment</u>		Ranked Sources of Workers	Ranked Areas for Shopping
	Given	Simulated	Given	Simulated		
North Pickering (14)	80,000	78,211	26,200	26,492	N. Pickering Scarboro N. Oshawa/Whitby	Ajax Scarboro N. Oshawa/Whitby
Oshawa/Whitby (16)	195,000	221,276	84,291	96,153	Oshawa/Whitby Ajax Pickering	Oshawa/Whitby Ajax Pickering
Scarborough N. (33)	140,866	155,738	31,449	38,921	Scarboro W. Scarboro N. East York	Toronto CBD York Scarboro W.
Toronto CBD (18)	161,148	145,904	347,743	250,999	Toronto W. Toronto N. East York	Toronto CBD Toronto N. York

Regional Population Correlation Co-efficient .97595

Regional Total Employment Correlation Co-efficient .97610

Areas of Population Pressure

Hamilton, Burlington, Erin-Mills-Meadowvale, Malton, Ajax, Oshawa/Whitby, parts of Metro Toronto - North York and Scarborough.

Results¹⁸ of Forecast I

The Forecast I set of computer runs has several implications for North Pickering. Given the assumptions of the Model and the conditions of Forecast I:

- North Pickering will have difficulty attaining its population goal.
- North Pickering will be attractive as an employment centre.
- Workers in North Pickering will reside primarily in North Pickering, Scarborough and Oshawa/Whitby.

d) North Pickering, Scarborough, Ajax and Oshawa/Whitby will be prime shopping areas for the residents of North Pickering.

4. Forecast II

The Forecast II computer set was designed to test the model simulation with a large role for North Pickering while attempting to provide a specific basic employment figure for each urban centre. Three different tests were made. Each test employed a different economic scenario for North Pickering. The major change from Forecast I is in the definition of basic employment.

Forecast I - Basic employment = manufacturing + wholesale
+ other + 50% of service.

Forecast II - Basic employment = manufacturing + wholesale
+ other + % of service.

The varying percentages of service classified as basic are indicated by urban centre in the following table.

TABLE 5

PERCENT OF SERVICE CLASSIFIED AS

BASIC BY URBAN CENTRE (Number and Name)

<u>80% of Service</u>	<u>60% of Service</u>	<u>50% of Service</u>	<u>40% of Service</u>	<u>20% of Service</u>
1. Hamilton 5	8. Malton	11. N. Metro Fringe	4. Oakville	2. Burlington
18. Toronto 1	19. Toronto W.	22. Toronto 5	5. Brampton- Bramalea	3. Milton
	20. Toronto York	24. Toronto 7	6. Mississauga	10. Woodbridge
	21. Toronto N.	26. Toronto 9	7. Erin Mills- Meadowvale	12. Markham Unionville
	36. Hamilton 4	27. Toronto 10	9. Richmond Hill	17. Bowmanville
		28. Toronto 11	13. Pickering	23. Toronto 6
		29. Toronto 12	15. Ajax	25. Toronto 8
		31. Toronto 14	16. Oshawa/ Whitby	30. Toronto 13
		32. Toronto 15		35. Hamilton 2
		33. Toronto 16		
		34. Hamilton 1		
		36. Hamilton 3		

The varying percentages were allocated on the basis of a perceived density of employment in the urban centres. Areas which are primarily residential received a smaller percentage of service employment allocated as basic employment. Areas of heavy manufacturing or concentrated commercial activity received a higher percentage of service to basic. This exercise was carried out in order to be more realistic about the allocation of basic employment.

Economic Scenario - North Pickering - Forecast II - IX

Population	103,000
Total employment	48,800
Basic employment	29,260
Non-basic employment	19,540
Population constraint	103,000
North Pickering activity rate	.473
Regional activity rate	.414
North Pickering non-basic employment to population rate	.189
Regional non-basic employment to population rate	.145

This scenario has the same rationale as Forecast I-IV in terms of total population and total employment. The basic/non-basic split was altered as only one-half the airport employment was considered basic in the quantification of basic employment. This is not theoretically correct since all airport employment is basic employment. However, an alternate basic/non-basic split was desired as a sensitivity test and this is how the numbers were obtained. In effect, this scenario tests North Pickering as a new town not as dependent on basic employment as in previous tests.

Selected results follow in Table 6.

TABLE 6

FORECAST II - IX SELECTED RESULTS

Zone	<u>Population</u>		<u>Total Employment</u>		Ranked Sources of Workers	Ranked Areas for Shopping
	Given	Simulated	Given	Simulated		
North Pickering (14)	103,000	82,335	48,800	47,241	N. Pickering Scarboro W. Scarboro N.	North Pickering Oshawa/Whitby Scarboro N.
Oshawa/Whitby (16)	195,000	218,541	84,291	87,721	Oshawa/Whitby Pickering Ajax	Oshawa/Whitby Ajax Pickering
Scarborough N. (33)	140,866	129,865	31,449	33,747	Scarboro W. East York Scarboro N.	Toronto CBD Scarboro W. Toronto N.
Toronto CBD (18)	161,148	163,016	347,743	313,844	Toronto W. Toronto N. East York	Toronto CBD Toronto N. York
Regional Population Correlation Co-efficient					.99137	
Regional Total Employment Correlation Co-efficient					.99692	

Areas of Population Pressure

Hamilton, Ajax, Oshawa/Whitby.

Economic Scenario - North Pickering - Forecast II - XI

Population	103,000
Total employment	48,800
Basic employment	40,560
Non-basic employment	8,240
Population constraint	103,000
North Pickering activity rate	.473
Regional activity rate	.414
North Pickering non-basic employment to population rate	.08
Regional non-basic employment to population rate	.142

This scenario is the same as the North Pickering scenario for Forecast I-IV. The only difference between the two tests is the difference in the basic/non-basic employment split for the region. As in Forecast I-IV, all airport employment is considered as basic employment.

Selected results follow in Table 7.

TABLE 7

FORECAST II - X SELECTED RESULTS

Zone	<u>Population</u>		<u>Total Employment</u>		Ranked Sources of Workers	Ranked Areas for Shopping
	Given	Simulated	Given	Simulated		
North Pickering (14)	103,000	82,829	48,800	48,765	N. Pickering Scarboro N. Scarboro W.	Oshawa/Whitby N. Pickering Scarboro N.
Oshawa/Whitby (16)	195,000	220,499	84,291	89,389	Oshawa/Whitby Pickering Ajax	Oshawa/Whitby Ajax Pickering
Scarborough N. (33)	140,866	130,087	31,449	34,371	Scarboro W. East York Scarboro N.	Toronto CBD Scarboro W. Toronto N.
Toronto CBD (18)	161,148	162,905	347,743	313,225	Toronto W. Toronto N. Toronto CBD	Toronto CBD Toronto N. Scarboro W.

Regional Population Correlation Co-efficient .99142

Regional Total Employment Correlation Co-efficient .99696

Areas of Population Pressure

Hamilton, Ajax, Oshawa/Whitby

Economic Scenario - North Pickering - Forecast II - XI

Population	80,000
Total employment	26,200
Basic employment	17,960
Non-basic employment	8,240
Population constraint	80,000
North Pickering activity rate	.327
Regional activity rate	.411
North Pickering non-basic employment to population rate	.103
Regional non-basic employment to population rate	.143

This scenario is the same as the North Pickering scenario for Forecast I-V. The only difference between the two runs is the basic/non-basic employment split. As with Forecast I-V, no airport is assumed in this scenario.

Selected results follow in Table 8.

TABLE 8

FORECAST II - XI SELECTED RESULTS

Zone	<u>Population</u>		<u>Total Employment</u>		Ranked Sources of Workers	Ranked Areas for Shopping
	Given	Simulated	Given	Simulated		
North Pickering (14)	80,000	59,002	26,200	25,248	N. Pickering Scarboro N. Scarboro W.	Oshawa/Whitby Scarboro N. N. Pickering
Oshawa/Whitby (16)	195,000	219,760	84,291	88,831	Oshawa/Whitby Pickering Ajax	Oshawa/Whitby Ajax Pickering
Scarborough N. (33)	140,866	126,455	31,449	33,517	Scarboro W. East York Scarboro N.	Toronto CBD Scarboro W. Toronto N.
Toronto CBD	161,148	164,052	347,743	313,878	Toronto W. Toronto N. Toronto CBD	Toronto CBD Toronto N. Scarboro W.

Regional Population Correlation Co-efficient .99080

Regional Total Employment Correlation Co-efficient .99689

Area of Population Pressure

Hamilton, Ajax, Oshawa/Whitby.

Results of Forecast II

The Forecast II set of computer runs has several implications for North Pickering. Given the Assumptions of the Model and the conditions of Forecast II:

- a) North Pickering is unattractive to population.
- b) North Pickering is attractive as an employment centre.
- c) Workers in North Pickering will reside primarily in North Pickering and Scarborough.
- d) North Pickering, Scarborough and Oshawa/Whitby will be prime shopping areas for the residents of North Pickering.

5. Forecast III

The Forecast III computer set was designed to test the model simulation with a smaller role for North Pickering and with alternate roles for Oshawa/Whitby while maintaining the

specific basic employment figures for all urban centres. This test was made at the request of the Regional Planning Branch, TEIGA. Two different tests were made. Each test employed a different scenario for Oshawa/Whitby. The following North Pickering scenario was used in both tests.

Economic Scenario - North Pickering - Forecast III

Population	40,000
Total employment	22,000
Basic employment	19,000
Non-basic employment	3,000
Population constraint	40,000
North Pickering activity rate	.55
North Pickering non-basic employment to population rate	.075

This scenario for North Pickering assumes an airport with 15,000 jobs. The activity rate is relatively large, reflecting the large role of the airport in the new town. The 40,000 population is a response to the airport and to housing pressure. The main emphasis in these two tests was on the role of Oshawa/Whitby.

Zone 18's (Toronto 1) percentage of service employment allocated to basic employment was increased from 80 percent to 100 percent. Zone 8's (Malton) percentage of service employment allocated to basic employment was increased from 60 percent to 80 percent.

The following table indicates the times which were altered for the Forecast III run. The times were altered in order to bring the preferred system (given) into line with the Regional Planning Branch's thinking.

TABLE 9

FORECAST III AND GENERAL DATA BASE TIMES
FOR ALTERED CONNECTIONS

Altered Connections	<u>Forecast III</u> <u>Times</u>		<u>General Data</u> <u>Base Times</u>	
	<u>Home to</u> <u>Work</u>	<u>Home to</u> <u>Shop</u>	<u>Home to</u> <u>Work</u>	<u>Home to</u> <u>Shop</u>
Hamilton to Oakville	41	33	44	35
Hamilton to Mississauga	55	45	60	48
Hamilton to CBD	99	75	89	60
Oakville to Mississauga	18	15	31	25
Oakville to CBD	60	48	59	40
Mississauga to Malton	20	16	32	25
Mississauga to CBD	36	30	44	32
Malton to CBD	60	48	54	35
Malton to North Pickering	57	47	59	40
CBD to Etobicoke	49	39	49	30
CBD to Toronto 11	48	38	47	30
CBD to Scarborough W.	50	40	40	25
CBD to North Pickering	60	48	65	43
CBD to Pickering	57	45	57	39
CBD to Oshawa/Whitby	87	70	73	50
Toronto II to North Pickering	15	13	46	31
North Pickering to Pickering	9	7	26	18
North Pickering to Oshawa/Whitby	36	30	34	24
Pickering to Oshawa/Whitby	30	24	27	18
Pickering to Ajax	8	6	18	12
Oshawa/Whitby to Ajax	16	12	20	14

The North Pickering to Pickering and North Pickering to Toronto 11 times have been altered significantly, in effect bringing these places closer together.

Economic Scenario - Oshawa/Whitby - Forecast III - XV

Population	195,000
Total employment	84,291
Basic employment	51,380
Non-basic employment	32,908
Population constraint	195,000
Oshawa/Whitby activity rate	.432
Regional activity rate	.414
Oshawa/Whitby non-basic employment to population rate	.168
Regional non-basic employment to population rate	.132

This scenario is the one used in all Forecast sets except for Forecast III - XVI. The population figure is slightly larger than the TCR trends and commitments figure, reflecting minor government intervention towards the ascendancy of Oshawa/Whitby as a nodal centre within the Central Ontario Region.

Selected results follow in Table 10.

TABLE 10

FORECAST III - XV SELECTED RESULTS

Zone	<u>Population</u>		<u>Total Employment</u>		Ranked Sources of Workers	Ranked Areas for Shopping
	Given	Simulated	Given	Simulated		
North Pickering (14)	40,000	30,679	22,000	21,914	N. York Central Pickering Scarboro N.	N. York C. Pickering Ajax
Oshawa/Whitby (16)	195,000	206,342	84,291	79,184	Oshawa/Whitby Ajax Pickering	Oshawa/Whitby Ajax Scarboro W.
Scarborough N. (33)	140,000	125,824	31,449	30,903	Scarboro W. East York Scaroboro N.	Scarboro W. Toronto N. York
Toronto CBD (18)	161,148	163,555	347,743	315,938	Toronto W. Toronto N. Toronto CBD	Toronto N. Mississauga York
Regional Population Correlation Co-efficient					.98996	
Regional Total Employment Correlation Co-efficient					.99404	

Areas of Population Pressure

Hamilton, Mississauga, Malton, Ajax, Oshawa/Whitby.

Economic Scenario - Oshawa/Whitby - Forecast III - XVI

Population	260,000
Total employment	111,982
Basic employment	67,973
Non-basic employment	44,009
Population constraint	260,000
Oshawa/Whitby activity rate	.430
Regional activity rate	.414
Oshawa/Whitby non-basic employment to population rate	.169
Regional non-basic employment to population rate	.132

The role of Oshawa/Whitby has been raised to 260,000 population. This represents a "goals" figure for Oshawa/Whitby, reflecting strong provincial intervention in the growth of Oshawa/Whitby. The activity rate and the non-basic employment to population rate were kept the same as for Forecast III - XV.

Selected results follow in Table 11.

TABLE 11

FORECAST III - XVI SELECTED RESULTS

Zone	Population		Total Employment		Ranked Sources of Workers	Ranked Areas for Shopping
	Given	Simulated	Given	Simulated		
North Pickering (14)	40,000	30,756	22,000	22,073	N. York Central Pickering Scarboro N.	N. York Cental Pickering Ajax
Oshawa/Whitby (16)	260,000	287,399	111,982	113,647	Oshawa/Whitby Ajax Pickering	Oshawa/Whitby Ajax Scarboro W.
Scarborough N. (33)	140,866	126,483	31,449	31,382	Scarboro W. East York Scarboro N.	Scarboro W. Oshawa/Whitby Toronto N.
Toronto CBD (18)	161,148	164,210	347,743	323,191	Toronto W. Toronto N. East York	Toronto N. Toronto CBD Mississauga
Regional Population Correlation Co-efficient					.99078	
Regional Total Employment Correlation Co-efficient					.99724	

Areas of Population Pressure

Hamilton, Mississauga, Malton, Ajax, Oshawa/Whitby.

Results of Forecast III

The Forecast III set of computer runs has several implications for North Pickering. Given the assumptions of the Model and the conditions of Forecast III:

- a) North Pickering is not attractive to population.
- b) North Pickering is attractive as an employment centre.
- c) Workers in North Pickering will reside primarily in North York, Scarborough and Pickering.
- d) North York, Pickering and Ajax will be prime shopping areas for the residents of North Pickering.
- e) Oshawa/Whitby is attractive to population.
- f) Oshawa/Whitby is attractive as an employment centre, despite the slight under allocation in Forecast III - XV.
- g) Workers in Oshawa/Whitby will reside primarily in Oshawa/Whitby, Ajax and Pickering.
- h) Oshawa/Whitby, Ajax and Scarborough will be prime shopping areas for the residents of Oshawa/Whitby.

6. Forecast IV

The Forecast IV computer set was designed to test the model simulation with a small role for North Pickering while maintaining the specific basic employment figures for all urban centres. One economic scenario was employed, but two tests were made; a population constrained test and a population unconstrained test. Population unconstrained is self-explanatory. Population constrained means that the Model is not allowed to over allocate the given population by more than a certain percentage (in this case 15%).

Economic Scenario - North Pickering - Forecasts IV-XVIII
IV-XIX

Population	25,000
Total employment	8,252
Basic employment	5,208
Non-basic employment	3,044
Population constraint	25,000
North Pickering activity rate	.330
Regional activity rate	.412
North Pickering non-basic employment to population rate	.121
Regional non-basic employment to population rate	.144

The scenario for North Pickering does not assume an airport. It represents a response to housing pressure. The figures are from the general data base.

Selected results are presented in Tables 12 and 13.

TABLE 12

FORECAST IV - XVIII SELECTED RESULTS

Zone	<u>Population</u>		<u>Total Employment</u>		Ranked Sources of Workers	Ranked Areas for Shopping
	Given	Simulated	Given	Simulated		
North Pickering (14)	25,000	17,096	8,252	7,395	Scarboro N. Scarboro W. Oshawa/Whitby	Oshawa/Whitby Scarboro N. Scarboro W.
Oshawa/Whitby (16)	195,000	220,581	84,291	88,899	Oshawa/Whitby Pickering Ajax	Oshawa/Whitby Ajax Pickering
Scarborough N. (33)	140,866	123,302	31,449	32,305	Scarboro W. East York Scarboro N.	Toronto CBD Scarboro W. Toronto N.
Toronto CBD (18)	161,148	164,326	347,743	314,669	Toronto W. Toronto N. East York	Toronto CBD Toronto N. Scarboro W.

Regional Population Correlation Co-efficient .99093
Regional Total Employment Correlation Co-efficient .99682

Areas of Population Pressure

Hamilton, Ajax, Oshawa/Whitby.

TABLE 13

FORECAST IV - XIX SELECTED RESULTS

Zone	<u>Population</u>		<u>Total Employment</u>		Ranked Sources of Workers	Ranked Areas for Shopping
	Given	Simulated	Given	Simulated		
North Pickering (14)	25,000	16,426	8,252	7,825	Oshawa/Whitby Scarboro N. Scarboro W.	Oshawa/Whitby Scarboro N. Scarboro W.
Oshawa/Whitby (16)	195,000	237,377	84,291	88,775	Oshawa/Whitby Ajax Pickering	Oshawa/Whitby Ajax Pickering
Scarborough N. (33)	140,866	121,206	31,449	31,818	Scarboro W. East York Scarboro N.	Toronto CBD Scarboro W. Oshawa/Whitby
Toronto CBD (18)	161,148	166,032	347,743	328,109	Toronto W. Toronto N. Toronto CBD	Toronto CBD Toronto N. Scarborough W.
Regional Population Correlation Co-efficient					.98705	
Regional Total Employment Correlation Co-efficient					.99880	

Areas of Population Pressure

None, due to maximum population over allocation of 100%
(population unconstrained run).

Results of Forecast IV

The Forecast IV set of computer runs has several implications for North Pickering. Given the assumptions of the Model and the conditions of Forecast IV:

- a) North Pickering is not attractive to population.
- b) North Pickering is slightly unattractive to employment.
- c) Workers in North Pickering will reside primarily in Scarborough and Oshawa/Whitby.
- d) Scarborough and Oshawa/Whitby will be prime shopping areas for the residents of North Pickering.

SECTION VII CONCLUSIONS

The Lowry Modelling Exercise has provided the North Pickering Project with an operational land use model which has spatial allocation features. To gain experience with the Model, as well as to better understand its internal structure, the Model was applied to the urban centres between Bowmanville and Hamilton including North Pickering. This has enabled the Economic staff to view North Pickering within its regional setting. It is relevant to point out the following; that the Model is not sophisticated to the desired degree; that the Model although based on empirical rules, does not have a strong theoretic foundation. With these caveats in mind some of the other general results of the Model will be stated. In general terms, the different tests have indicated that North Pickering will not be as attractive to population as the goals indicate (this is especially true for the lowest population goal) but will be attractive as an employment centre, especially if an airport is included within the scenario for North Pickering. The Model indicated that the larger the role for North Pickering the more attractive it becomes to population and employment. The Model has also indicated that large scale commuting exists within the region. This point has been confirmed by referencing MTC's origin and destination trip data.

The Model indicated that Hamilton, Ajax and Oshawa/Whitby were consistently attractive to population. However, some of the smaller centres in the region, (Milton, Richmond Hill, Markham-Unionville, and Bowmanville) were consistently unattractive to population.

The Model indicated that Hamilton, Pickering and Ajax were consistently attractive as employment centres. However,

some of the smaller centres in the region (Milton, Richmond Hill, Markham-Unionville and Bowmanville) were consistently unattractive as employment centres.

The Model indicated that those who work in North Pickering will come mainly from Scarborough and Oshawa/Whitby, as well as North Pickering. The Model also indicated that those who live in North Pickering will shop mainly in Oshawa/Whitby, Ajax, Scarborough as well as North Pickering.

Within the region, the Model indicated that there were four major work and shop nodes. Hamilton, Mississauga, Metro Toronto and Oshawa/Whitby. In considering the role of North Pickering vis-a-vis Oshawa/Whitby, the Model indicated that Oshawa/Whitby would be attractive to population, regardless of the size of North Pickering.

The results of the first phase of the Iterative Lowry Modelling Exercise are being released for two reasons:

1. to circulate the information contained in the report.
2. to obtain comments (favourable and unfavourable) about the Model in the planning exercise.

PHASE II

The Economic Planning staff has now entered Phase II of the Iterative Lowry Modelling Exercise. The main emphasis in Phase II will be placed on disaggregating the Model and applying the disaggregated version to a sub-regional setting i.e. east of Metro Toronto. With this format more attention will be placed on North Pickering and a specific service employment breakdown will be generated. Once again, the exercise will be to attempt to simulate a preferred situation and then to alter policy variables to determine their consequences on North Pickering and on the Sub-Region.

SECTION VIII

FOOTNOTES

1. I.S. Lowry, A Model of Metropolis, The Rand Corporation, Santa Monica, California, 1964.
2. Wm. Goldner "The Lowry Model Heritage" Journal of the American Institute of Planners, March 1971.
3. Definitions liberally borrowed from; M. Cordey-Hayes, T. Broadbent, D. Massey, "Towards Operational Urban Development Models", Colstan Papers, Regional Forecasting, 1971 p.240.
4. H. Blumenfeld, "The Economic Base of the Metropolis", Journal of the American Institute of Planners, #21.
5. A.G. Wilson, "Generalizing the Lowry Model," from A.G. Wilson, edit., Urban and Regional Planning, 1971 p.124.
6. M. Cordey-Hayes, et al., p.235.
7. See Chart II - Appendix - Urban Centres
8. See Chart III - Appendix - Population Data by number and name for the Urban Centres
9. See Chart V - Appendix - Home to Shop Link Diagrams.
10. The following report was used as a source document for this section: R.M. Hodgins, Users Guide to a Computer Program for the Disaggregation of the Iterative Lowry Model, University of Waterloo, Summer 1973.
11. See the following two articles: G.M. Hyman, "The Calibration of Trip Distribution Models" Environment and Planning, Vol. 1, 1969; M. Batty "Some Problems of Calibrating the Lowry Model", Environment and Planning, Vol. 2, 1970, pp. 95-114.
12. See Chart II - Appendix.
13. The off-peak times used were a factor of peak travel times as the actual off-peak data was not available at the time of the modelling exercise.
14. Government source documents: Ministry of Transportation and Communications, Planning Division, Socio-Economic Data 1971, T.A.R.M.S., May 1973; Ministry of Treasury, Economics and Intergovernmental Affairs, Regional Development Branch, Toronto Centred Region Zone 1 and North South Axis Vol. 1, September 1972; Ministry of Treasury, Economics and Intergovernmental Affairs, Regional Development Branch, Compiled Notes Concerning RDB, Reviews of MTC's Employment Allocation for Zone 1, December 1972.
15. See Chart VI - Appendix - Urban Centres by Transportation District.
16. An examination of the equations in Section IV will enable the reader to better understand the results of the model.
17. A 15% maximum population over allocation error was used in all tests except the Forecast IV test.
18. See % over and under allocation for population and total employment in Chart IV - Appendix.

PART C

SECTION IX THE APPENDIX

1. Chart I Lowry Model Computer Equations
2. Chart II A Urban Centres
 Chart II B Metro Toronto Urban Centres
3. Chart III 1986 Population
4. Chart IV A Per Cent Population Results
 Chart IV B Per Cent Employment Results
5. Chart V Home to Shop Links
6. Chart VI Urban Centres by Transportation District
7. Chart VII 1986 Raw Data

CHART I

APPENDIX

ITERATIVE LOWRY MODEL COMPUTER EQUATIONS

Sub Model I

$$T_{ij}^W = e_i \cdot k \cdot \frac{H_j \cdot F_{ij}^W}{\sum_j H_j \cdot F_{ij}^W}$$

$$\sum_j T_{ij}^W = P_j \quad \text{Where } i = j$$

Sub Model II

$$T_{ij}^S = P_i \cdot m \cdot \frac{e_j^S \cdot F_{ij}^S}{\sum_j e_j^S \cdot F_{ij}^S} \quad \text{Where } i = j$$

$$\sum_j T_{ij}^S = e_j^S$$

Link I & II

$$e^b + e_j^S = e_i$$

Work to Home Link

$$T_{ij}^{gW} = e_i \cdot g^W \cdot \frac{H_j \cdot F_{ij}^W}{\sum_j H_j \cdot F_{ij}^W}$$

Home to Shop Link

$$T_{ij}^{gS} = P_i \cdot g^S \cdot \frac{e_j^S \cdot F_{ij}^S}{\sum_j e_j^S \cdot F_{ij}^S}$$

Where

- T_{ij}^W - Work to Home Link
- e_i - Total Employment
- k - Inverse of Activity Rate (Population/Total Employment)

- H_j - Population Attractivity Factor
(Population constraint)

- F_{ij}^W - Work Travel Time Factor

$$F_{ij}^W = e^{-\alpha d_{ij}^W}$$

Where

- α - Work Trip Sensitivity Parametre
- d_{ij}^W - Travel times for work to home trip.

- T_{ij}^S - Home to Shop Link

- P_i - Population

- m - Non Basic Employment to Population Ratio

- e_j^S - Non Basic Employment

- F_{ij}^S - Shop Travel Time Factor

$$F_{ij}^S = e^{-\beta d_{ij}^S}$$

Where

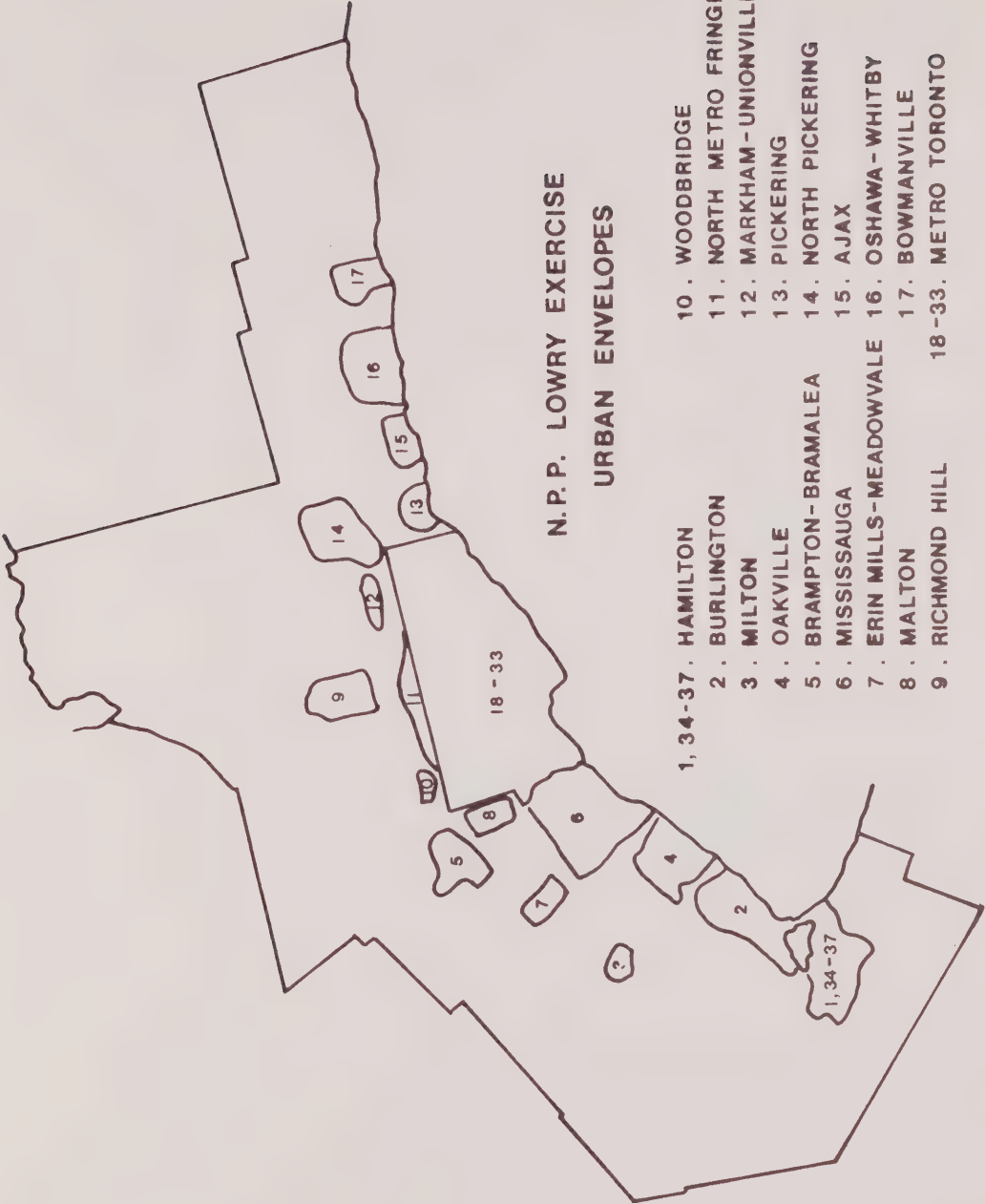
- β - Shop Trip Sensitivity Parametre
- d_{ij}^S - Travel times for home to shop trip

- g^W - Work trip generation rate

- g^S - Shop trip generation rate

- T_{ij}^{gW} - work to home link distributed from work zone i to residential zone j.

- T_{ij}^{gS} - home to shop link distributed from residential zone i to shop zone j.



N.P.P. LOWRY EXERCISE
URBAN ENVELOPES

- | | |
|--------------------------|------------------------|
| 1, 34-37. HAMILTON | 10. WOODBRIDGE |
| 2. BURLINGTON | 11. NORTH METRO FRINGE |
| 3. MILTON | 12. MARKHAM-UNIONVILLE |
| 4. OAKVILLE | 13. PICKERING |
| 5. BRAMPTON-BRAMALEA | 14. NORTH PICKERING |
| 6. MISSISSAUGA | 15. AJAX |
| 7. ERIN MILLS-MEADOWVALE | 16. OSHAWA-WHITBY |
| 8. MALTON | 17. BOWMANVILLE |
| 9. RICHMOND HILL | 18-33. METRO TORONTO |

CHART II B (See next page)

METRO TORONTO BREAKDOWN

<u>Zone #</u>	<u>Zone Name</u>		
18	Metro Toronto	1	Toronto CBD
19		2	Toronto W.
20		3	York
21		4	Toronto N.
22		5	North York S.
23		6	East York
24		7	Etobicoke S.
25		8	Etobicoke Central
26		9	Etobicoke N.
27		10	North York W.
28		11	North York Central
29		12	North York E.
30		13	Scarborough W.
31		14	Scarborough S.
32		15	Scarborough E.
33		16	Scarborough N.

Hamilton Breakdown by Name

<u>Zone #</u>			
1	Hamilton	5	Hamilton CBD, City
34	Hamilton	1	Dundas & Ancaster
35	Hamilton	2	Hamilton Mountain
36	Hamilton	3	Stoney Creek Area
37	Hamilton	4	Bayfront Industry

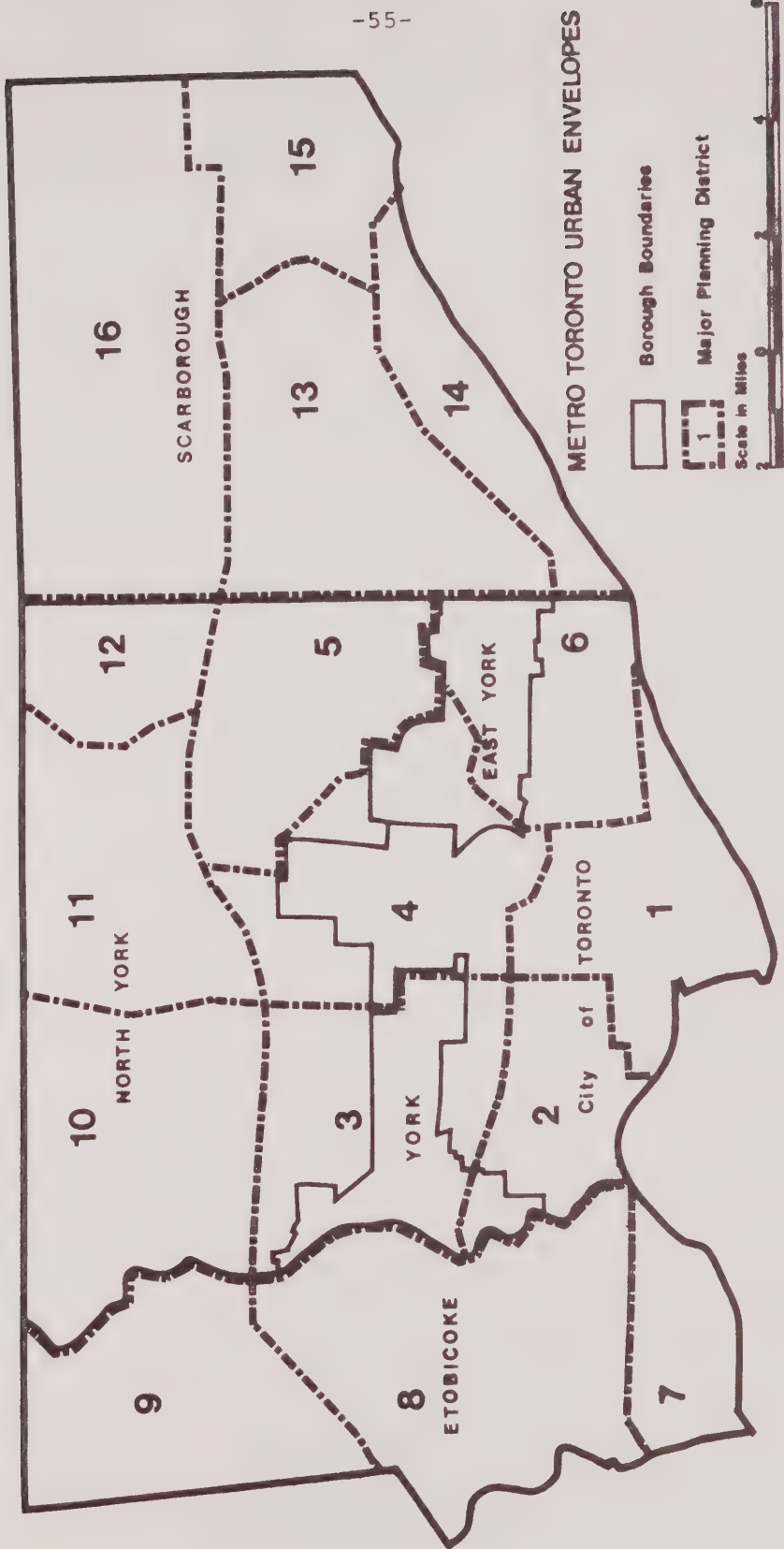


CHART III

1986 - POPULATION

<u>Zone #</u>	<u>Zone Name</u>	<u>Population</u>
1	Hamilton 5	168,000
2	Burlington	124,000
3	Milton	10,000
4	Oakville	80,000
5	Brampton-Bramalea	100,000
6	Mississauga	240,000
7	Erin Mills-Meadowvale	54,000
8	Malton	20,000
9	Richmond Hill	50,000
10	Woodbridge	8,000
11	North Metro Fringe	50,000
12	Markham-Unionville	18,000
13	Pickering	58,000
14	North Pickering	-
15	Ajax	24,000
16	Oshawa/Whitby	195,000
17	Bowmanville	12,000
18	Metro Toronto 1	161,148
19	2	269,272
20	3	273,696
21	4	243,954
22	5	128,778
23	6	267,311
24	7	71,050
25	8	196,448
26	9	76,940
27	10	149,059
28	11	167,631
29	12	76,669
30	13	222,594
31	14	82,907
32	15	64,163
33	16	140,866
34	Hamilton 1	56,000
35	Hamilton 2	129,000
36	Hamilton 3	43,000
37	Hamilton 4	22,000

Source: Regional Planning Branch, TEIGA
 NPP calculation for Metro and Hamilton.
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CHART IV-A

PER CENT POPULATION RESULTS

POPULATION	FORECAST I		FORECAST II				FORECAST III		FORECAST IV		ZONE
	NP 103,000	NP 80,000	NP 103,000	NP 103,000	NP 80,000	NP No Airport	O/W 195,000	O/W 260,000	NP 25,000	NP 25,000	
			Altered Basic	Airport Basic	No Airport				Const- rained	Unconst- strained	
	IV	V	IX	X	XI		XV	XVI	XVIII	XIX	
Ham. 5	7%↑	7%↑	11%↑	11%↑	11%↑		12%↑	10%↑	11%↑	25%↑	1
Bur.	7%↑	14%↑	1%↑	1%↑	1%↑		1%	3%	1%↑	7%	2
Milton	2%↑	2%↑	33%	34%	33%		34%	34%	33%	34%	3
Oak.	1%	1%↑	10%	10%	10%		5%↑	2%↑	10%	15%	4
Bramp-Br.	9%↑	11%↑	4%	4%	4%		2%	4%	3%	5%	5
Miss.	10%↑	11%↑	8%↑	7%↑	8%↑		7%↑	6%↑	8%↑	6%↑	6
Erin Mills	10%↑	11%↑	9%	9%	8%		8%	9%	8%	10%	7
Malton	9%↑	11%↑	9%↑	9%↑	9%↑		4%↑	2%↑	9%↑	8%↑	8
Rich-Hill	32%	33%	34%	33%	35%		35%	35%	35%	36%	9
Wood.	8%	7%	11%	10%	10%		10%	11%	10%	12%	10
N.M.F.	17%	18%	19%	19%	20%		21%	21%	21%	22%	11
MK-UN.	23%	27%	25%	25%	29%		31%	31%	33%	34%	12
Pick.	12%↑	10%↑	3%↑	4%↑	1%↑		3%↑	4%↑	2%↑	9%↑	13
N. Pick.	6%	3%	21%	20%	27%		24%	24%	32%	35%	14
Ajax	11%↑	13%↑	11%↑	12%↑	12%↑		8%↑	11%↑	13%↑	28%↑	15
O/W	11%↑	13%↑	12%↑	13%↑	12%↑		5%↑	10%↑	13%↑	21%↑	16
Bow.	1%↑	1%↑	20%	20%	20%		18%	12%	19%	25%	17

↑ indicates increase
no ↑ indicates decrease

	FORECAST I		FORECAST II			FORECAST III		FORECAST IV		ZONE
	IV	V	IX	X	XI	XV	XVI	XVIII	XIX	
Toronto 1	8%	10%	1%	1%	1%	1%	1%	2%	3%	18
" 2	3%	3%	1%	1%	2%	2%	2%	2%	2%	19
" 3	7%	7%	6%	6%	6%	7%	6%	7%	6%	20
" 4	5%	6%	1%	1%	1%	1%	1%	1%	1%	21
" 5	14%	15%	2%	2%	3%	0%	3%	3%	3%	22
" 6	14%	16%	1%	1%	1%	1%	1%	1%	1%	23
" 7	1%	1%	2%	2%	1%	1%	2%	1%	2%	24
" 8	36%	36%	1%	1%	1%	2%	1%	1%	-	25
" 9	8%	9%	4%	4%	4%	5%	4%	4%	3%	26
" 10	7%	7%	1%	1%	1%	1%	2%	2%	3%	27
" 11	11%	10%	4%	4%	4%	2%	1%	5%	5%	28
" 12	5%	4%	6%	6%	5%	6%	6%	4%	3%	29
" 13	7%	9%	6%	6%	7%	16%	16%	8%	8%	30
" 14	5%	3%	8%	8%	9%	10%	9%	10%	11%	31
" 15	9%	9%	22%	20%	24%	24%	24%	26%	27%	32
" 16	10%	10%	8%	8%	10%	11%	11%	13%	14%	33
Ham. 1	7%	7%	6%	6%	6%	6%	4%	6%	12%	34
Ham. 2	3%	6%	1%	1%	1%	1%	9%	12%	1%	35
Ham. 3	12%	6%	5%	4%	5%	4%	2%	5%	14%	36
Ham. 4	14%	1%	8%	8%	9%	12%	11%	8%	2%	37

↑ indicates increase
no ↑ indicates decrease

CHART IV-B

PER CENT EMPLOYMENT RESULTS

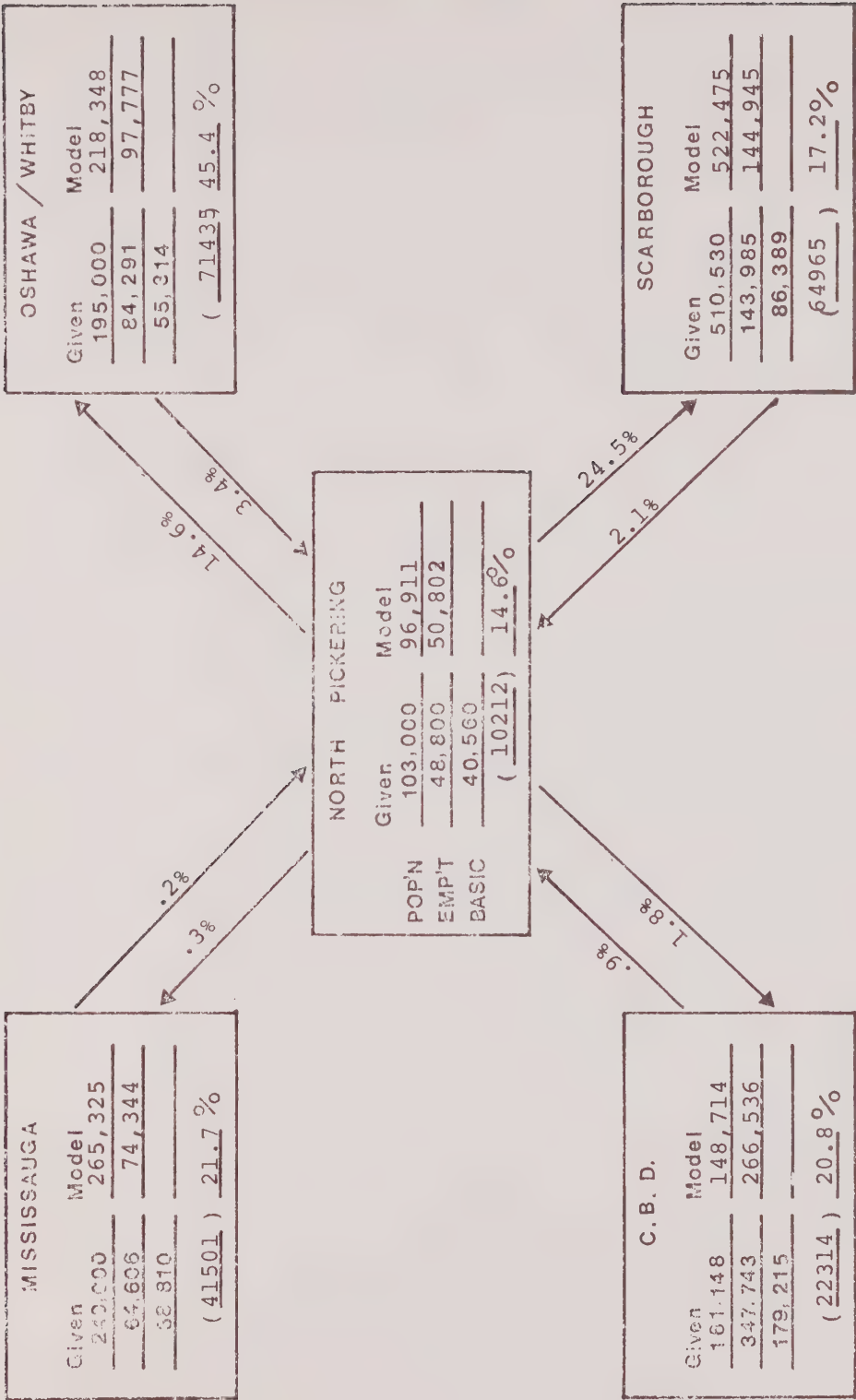
↑	indicates increase
no ↑	indicates decrease

ZONE	FORECAST I			FORECAST II			FORECAST III			FORECAST IV		
	103,000	80,000	V	103,000-1/2	103,000	X	80,000	195,000	260,000	15%	XVIII	XIX
	IV			IX			XI	XV	XVI			
1	1%	1%	1%	5%	4%	5%	5%	1%	2%	5%	5%	6%
2	33%	29%	29%	22%	20%	21%	21%	13%	11%	22%	22%	14%
3	24%	29%	29%	29%	30%	15%	15%	39%	31%	29%	29%	17%
4	6%	7%	7%	3%	2%	2%	2%	11%	9%	3%	3%	2%
5	10%	13%	13%	3%	3%	3%	3%	1%	1%	3%	3%	1%
6	15%	20%	20%	9%	8%	9%	9%	32%	21%	9%	9%	4%
7	1%	1%	1%	3%	3%	3%	3%	8%	5%	2%	2%	1%
8	16%	22%	22%	6%	6%	6%	6%	11%	7%	6%	6%	2%
9	21%	26%	26%	20%	19%	20%	20%	28%	21%	21%	21%	12%
10	13%	16%	16%	13%	13%	13%	13%	19%	14%	13%	13%	8%
11	4%	7%	7%	5%	5%	6%	6%	10%	7%	7%	7%	4%
12	1%	5%	5%	7%	5%	9%	9%	21%	15%	14%	14%	8%
13	15%	109%	109%	35%	40%	36%	36%	22%	16%	31%	31%	16%
14	4%	1%	1%	4%	1%	4%	4%	1%	0%	11%	11%	6%
15	155%	239%	239%	59%	65%	62%	62%	227%	130%	59%	59%	26%
16	16%	14%	14%	4%	6%	5%	5%	7%	1%	5%	5%	5%
17	27%	32%	32%	31%	30%	30%	30%	39%	30%	30%	30%	16%
18	24%	28%	28%	10%	10%	10%	10%	10%	8%	10%	10%	6%
19	11%	13%	13%	6%	6%	6%	6%	8%	6%	5%	5%	3%
20	1%	1%	1%	1%	1%	1%	1%	0%	0%	-	-	-
21	3%	4%	4%	2%	2%	2%	2%	1%	1%	2%	2%	2%
22	1%	1%	1%	2%	1%	2%	2%	2%	2%	2%	2%	2%
23	16%	20%	20%	15%	15%	15%	15%	19%	14%	15%	15%	9%
24	2%	3%	3%	1%	1%	1%	1%	1%	1%	1%	1%	-
25	8%	11%	11%	6%	6%	6%	6%	4%	2%	7%	7%	4%
26	11%	15%	15%	5%	5%	5%	5%	7%	4%	6%	6%	2%
27	5%	7%	7%	2%	2%	2%	2%	3%	1%	2%	2%	1%
28	5%	7%	7%	1%	1%	1%	1%	10%	6%	1%	1%	1%
29	21%	27%	27%	10%	10%	9%	9%	12%	7%	8%	8%	3%
30	4%	7%	7%	7%	6%	7%	7%	14%	10%	8%	8%	5%
31	6%	10%	10%	9%	8%	9%	9%	17%	12%	11%	11%	6%
32	9%	15%	15%	12%	10%	12%	12%	21%	14%	13%	13%	8%
33	22%	23%	23%	7%	9%	6%	6%	2%	1%	2%	2%	1%
34	70%	99%	99%	44%	41%	43%	43%	48%	32%	43%	43%	22%
35	15%	17%	17%	26%	24%	25%	25%	17%	15%	26%	26%	19%
36	11%	12%	12%	14%	13%	13%	13%	11%	9%	13%	13%	10%
37	1%	2%	2%	1%	1%	1%	1%	2%	1%	-	-	-

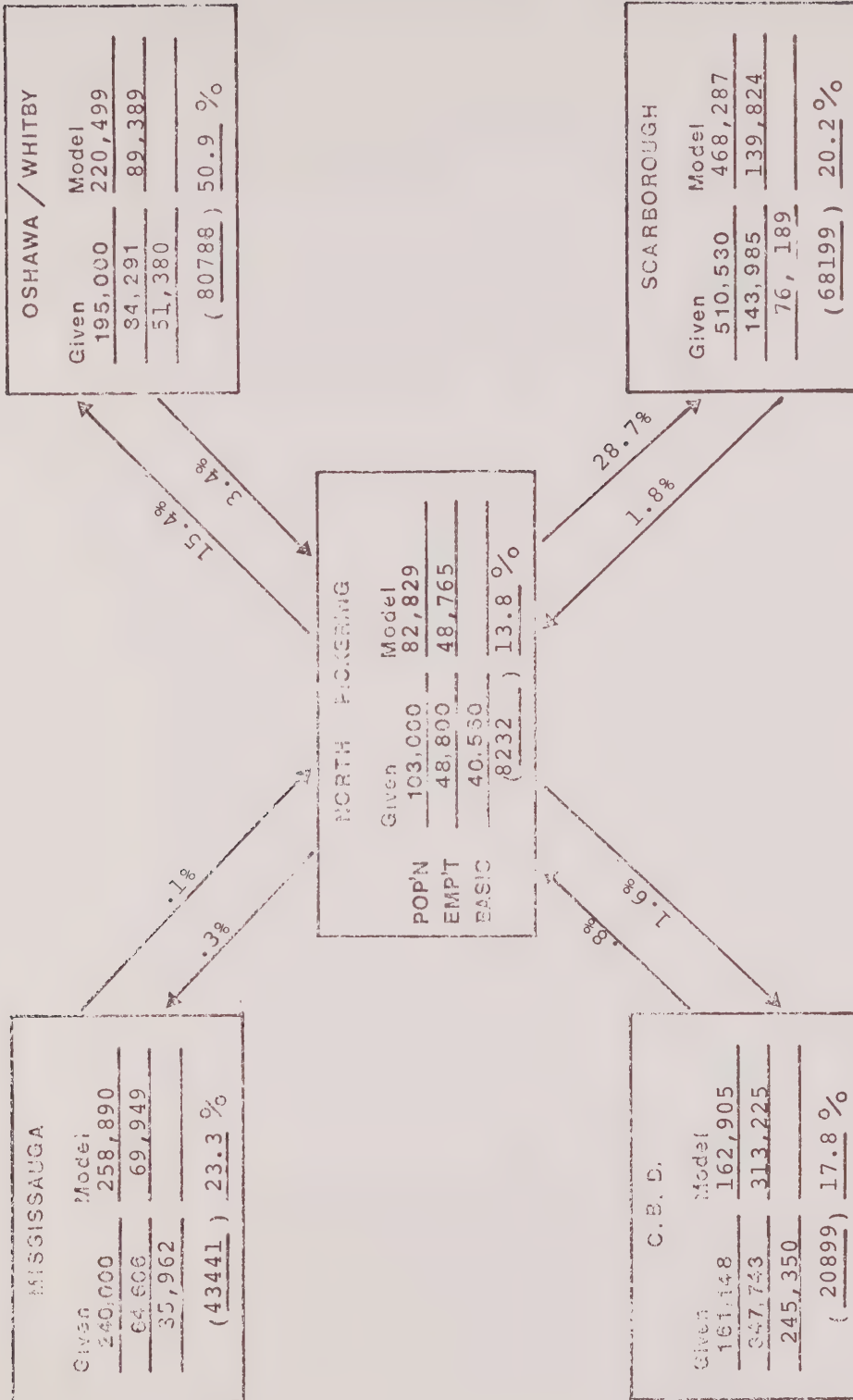
CHART V

HOME TO SHOP LINKS

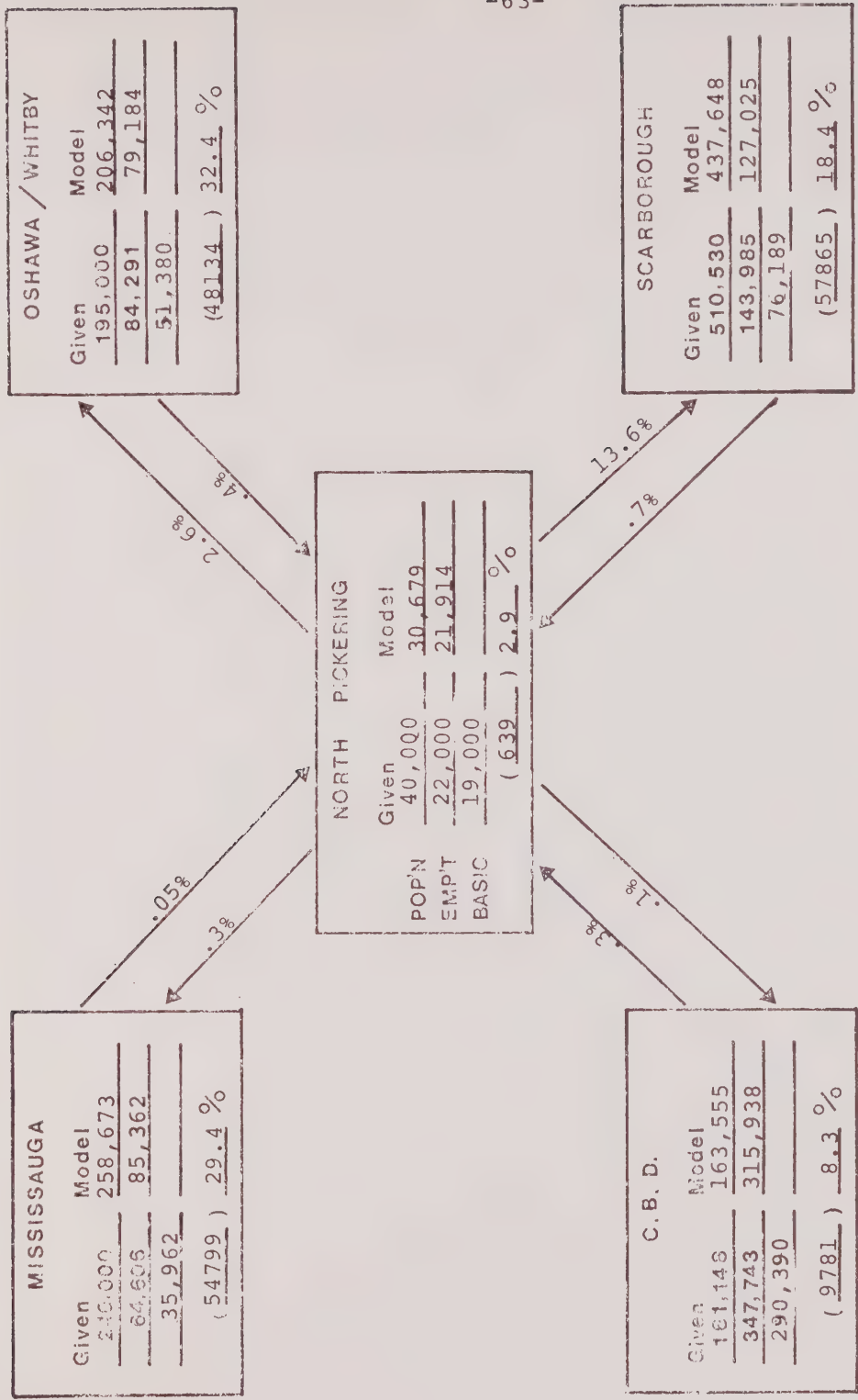
The following Diagrams are similar in form to the Work to Home Diagrams in Part A. For selected urban centres, the given population, total employment and basic employment figures are present in the first column. In the second column, the population and total employment model results are presented. The figure in the brackets is the number of people who live and shop within that urban centre. The per cent figure is the number of people who live and shop in an urban centre as a per cent of the population who travel to shop in that urban centre. The arrows reflect the flow of shoppers to an urban centre as a per cent of the shoppers from their home urban centre.



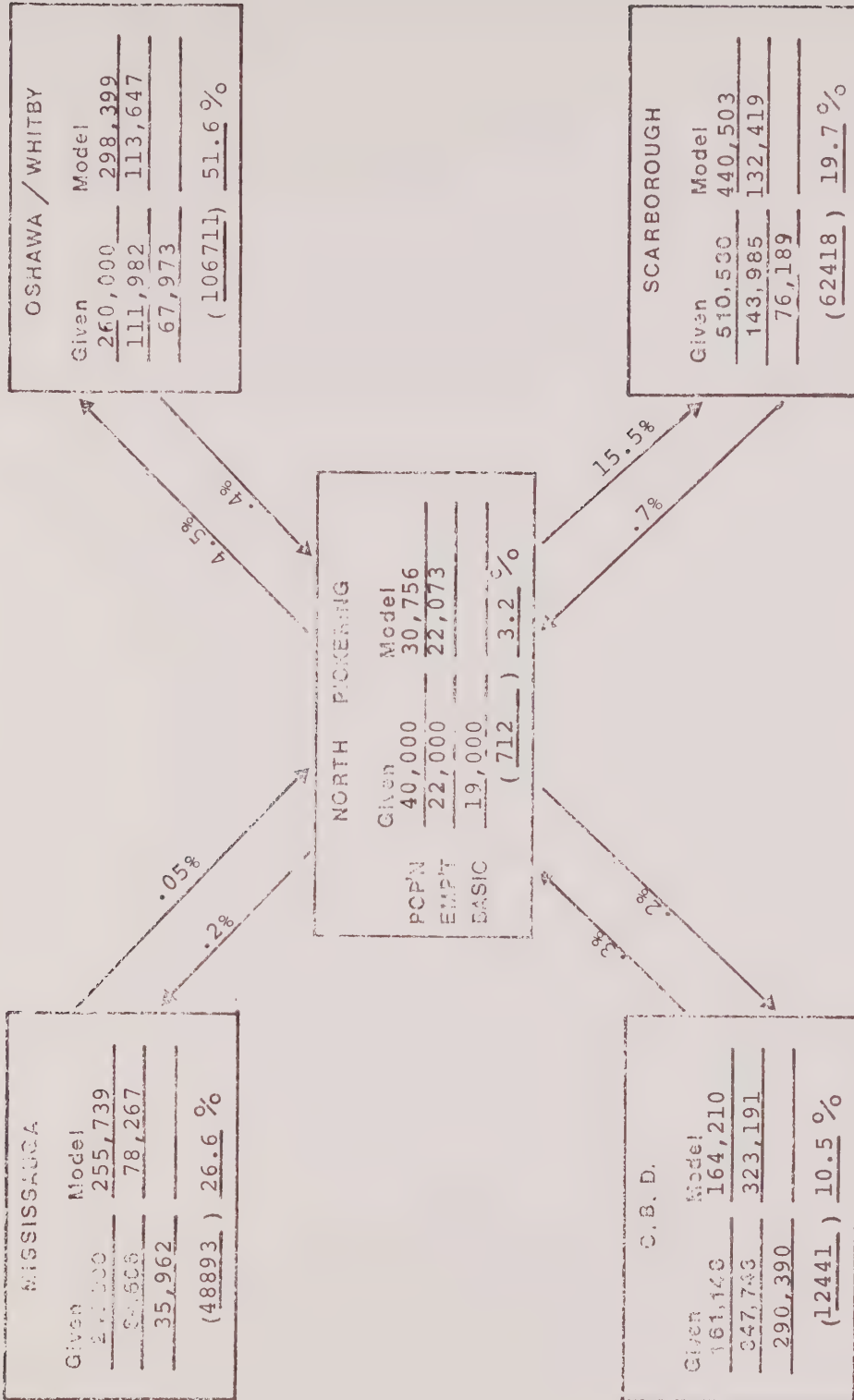
FORECAST I IV
HOME TO SHOP FLOW
AS A % OF TOTAL WORK FLOWS



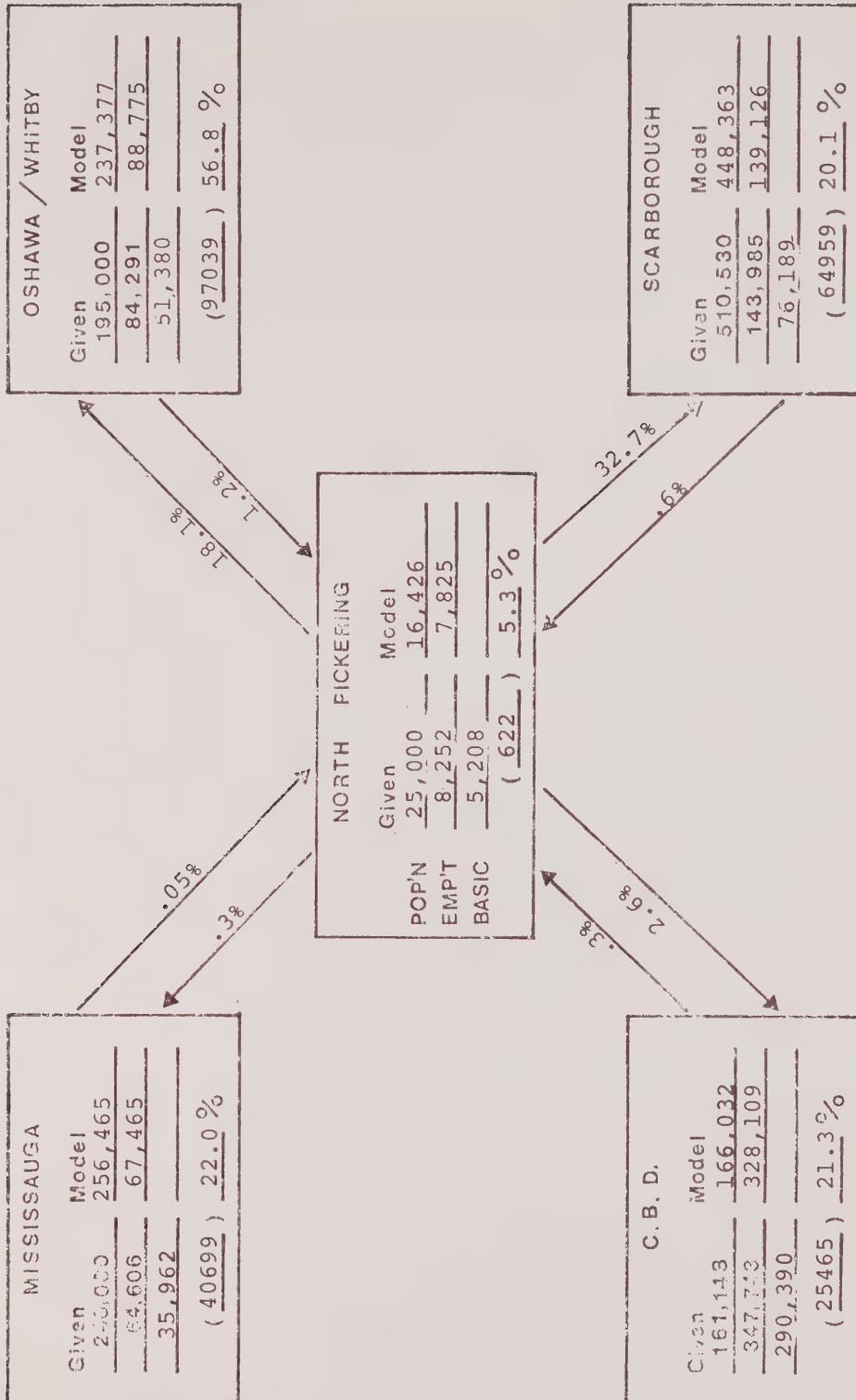
FORECAST II -X
HOME TO SHOP FLOW
AS A % OF TOTAL WORK FLOWS



FORECAST III -XV
HOME TO SHOP FLOW
AS A % OF TOTAL WORK FLOWS



FORECAST III-XVI
HOME TO SHOP FLOW
AS A % OF TOTAL WORK FLOWS



FORECAST IV - XIX
HOME TO SHOP FLOW
AS A % OF TOTAL WORK FLOWS

CHART VI

URBAN CENTRES BY

TRANSPORTATION DISTRICT

(See next page)



TRANSPORTATION DISTRICT

CHART VII

1986 - RAW DATA *

<u>Zone</u>	<u>Total Employment</u>	<u>Manufacturing & Wholesale</u>	<u>Retail</u>	<u>Service</u>	<u>Other</u>	<u>Population Constraints</u>	<u>Zone</u>
Hamilton 5	90,000	21,444	15,276	53,278	2	170,000	1
Burlington	34,904	13,200	6,189	15,125	390	150,000	2
Milton	4,559	1,646	584	2,278	51	15,000	3
Oakville	23,515	12,237	4,259	6,947	72	85,000	4
Brampton- Bramalea	31,827	19,217	3,052	9,313	245	110,000	5
Mississauga	64,606	24,463	11,549	28,491	103	240,000	6
Erin Mills	14,458	7,779	2,193	4,151	335	100,000	7
Malton	30,635	17,902	930	11,801	2	25,000	8
Richmond Hill	10,708	3,786	2,162	4,531	229	50,000	9
Woodbridge	1,766	786	299	670	11	8,000	10
North Metro Fringe	14,503	6,769	2,721	4,940	73	50,000	11
Markham- Unionville	3,505	1,617	836	1,007	45	18,000	12
Pickering	9,642	2,579	1,937	4,889	237	58,000	13
North Pickering	8,252	3,768	944	3,499	41		14
Ajax	7,144	3,742	1,429	1,934	39	24,000	15
Oshawa- Whitby	84,291	37,417	12,293	34,362	219	195,000	16
Bowmanville	3,368	1,470	643	1,253	2	14,000	17

* GENERATED FOR MODELLING PURPOSES ONLY.

CHART VII Cont'd

Toronto 1	347,743	65,192	57,353	225,196	2	150,000	18
2	64,032	27,082	14,516	22,433	1	260,000	19
3	109,252	59,376	22,687	27,187	2	274,000	20
4	90,659	17,139	15,752	57,766	2	210,000	21
5	50,870	24,917	7,047	18,903	3	112,000	22
6	47,189	18,759	12,768	15,659	3	259,000	23
7	53,792	32,803	8,089	12,897	3	72,000	24
8	72,637	37,431	11,348	23,856	2	122,000	25
9	57,466	43,856	5,964	7,645	1	100,000	26
10	70,533	47,159	7,031	16,341	2	182,000	27
11	32,363	3,279	12,000	17,081	3	191,000	28
12	11,802	2,482	1,747	7,571	2	88,000	29
13	88,742	44,578	16,562	27,600	2	219,000	30
14	11,283	1,090	4,796	5,397	0	94,000	31
15	12,511	2,727	2,033	7,749	2	105,000	32
16	31,449	9,915	9,970	11,561	3	227,000	33
Hamilton 1	13,700	3,341	1,845	8,440	74	60,000	34
2	16,900	2,895	2,776	11,225	4	130,000	35
3	8,300	4,158	1,325	2,434	383	45,000	36
4	52,100	44,582	799	6,715	2	22,000	37

PART D

SECTION X

BIBLIOGRAPHY

Articles and Books

Batty, M., "Some Problems of Calibrating the Lowry Model", Environment and Planning, Vol. 2, 1970.

"The Impact of a New Town" Journal of the Royal Town Planning Institute, December 1969.

Blumenfeld, H., "The Economic Base of the Metropolis", Journal of the American Institute of Planners, #21.

Cordey-Hayes, M., Broadbent, T., Massey, D., "Towards Operational Urban Development Models, Colstan Papers, Regional Forecasting, 1971.

Cripps, E.L., and Foot, D.H.S., "A Land Use Model for Sub-Regional Planning", Regional Studies Vol. 3, 1969.

Goldner, Wm. "The Lowry Model Heritage", Journal of the American Institute of Planners, March, 1971.

Hodgins, R., User's Guide to a Computer Program for the Disaggregation of the Iterative Lowry Model, University of Waterloo, Summer, 1973.

Hyman, G.M., "The Calibration of Trip Distribution Models", Environment and Planning Vol. 2, 1970.

Lowry, I.S., A Model of Metropolis, The Rand Corporation Santa Monica California, 1964.

* Ministry of Transportation and Communications, Planning Division, Socio-Economic Data 1971, May 1973.

* Ministry of Treasury, Economics and Intergovernmental Affairs, Regional Development Branch, Toronto Centred Region Zone 1 and North South Axis, Vol. 1, Sept., 1972.

* Ministry of Treasury, Economics and Intergovernmental Affairs, Regional Development Branch, Compiled Notes Concerning RDB Reviews of MTC's Employment Allocation for Zone 1, December, 1972.

Wilson, A.G., "On Some Problems in Urban and Regional Modelling" in Regional Forecasting Colstan Papers, Archon Books, 1971.

Wilson, A.G., "Generalizing The Lowry Model", in Wilson, A.G., edit., Urban and Regional Planning, 1971.

* Internal Working Papers.



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